1167E

AN ECONOMIC STUDY
ON
IMPROVED MANAGEMENT
OF
DRY CLEANING
INDUSTRY WASTES

DECEMBER 1990

Environment
Environnement
Ontario

ISBN 0-7729-7422-5

AN ECONOMIC STUDY ON IMPROVED MANAGEMENT OF DRY CLEANING INDUSTRY WASTES

Report prepared by:
Moneco Consultants Limited
in association with
The DPA Group

Report prepared for:
Waste Management Branch
Ontario Ministry of the Environment

DECEMBER 1990

RECYCLABLE

Cette publication technique
n'est disponible qu'en anglais

Copyright: Queen's Printer for Ontario, 1990
This publication may be reproduced for non-commercial purposes
with appropriate attribution

PIBS 1167
log 89-2425-002

DISCLAIMER

This report was prepared for the Ontario Ministry of the Environment as part of a ministry-funded project. The views and ideas expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

Some types of Ontario dry cleaning industry wastes are currently being mismanaged. Of particular significance, filter cartridges containing perchloroethylene are mostly being disposed of in non-hazardous landfill. This has potentially serious implications for ground water quality in the vicinity of those landfills.

This study investigated the technological options available to the dry cleaning industry to reduce the amounts of solvents (perchloroethylene and petroleum) being disposed of in wastes. The anticipated performance of the technologies was evaluated and an economic assessment of the highest ranked options was performed.

In terms of the economics of dry cleaning operations, it was concluded that the recommended options of off-site reclamation of wastes would not significantly impact the economic health of the industry. Costs for waste management could be easily passed-on to consumers and demand for dry cleaning services would not be affected.

The majority of perchloroethylene still bottoms are presently well managed by a waste reclamation infrastructure in Ontario. Such an infrastructure is not currently in place in Ontario to reclaim materials from cartridge wastes. These services are currently in place in other Provinces and in the United States and several companies have expressed interest in establishing dry cleaning waste reclamation services in Ontario.

TABLE OF CONTENTS

Letter of Transmittal

Executive Summary

		PAGE
Table of Contents		(i)
PART 1 - BACKGROUND		1-1
PART 2 - WASTE MANAGEMENT OPTIONS		
2.1	INTRODUCTION	2-1
2.2	WASTE COMPONENTS AND DISPOSITION OPTIONS	2-1
2.3	TREATMENT TECHNOLOGIES	2-4
2.4	TECHNOLOGY PERFORMANCE DATA	2-5
2.5	EVALUATION OF TECHNOLOGIES	2-11
2.6	ON-SITE VS. OFF-SITE TREATMENT	2-16
PART 3 - ECONOMIC ASSESSMENT OF THE MOST EFFECTIVE WASTE MANAGEMENT OPTIONS		
3.1	INTRODUCTION	3-1
3.2	ECONOMICS OF TYPICAL PLANTS	3-2
3.3.	COST OF STILL BOTTOMS TREATMENT AND DISPOSAL	3-5
3.4	CARTRIDGE DISPOSAL OPETIONS - PERCHLOROETHYLENE PLANTS	3-6
	3.4.1. OFF-SITE TREATMENT OF CARTRIDGES	3-9
	3.4.2. OFF-SITE DISPOSAL	3-13
	3.4.3. ON-SITE TREATMENT	3-16
	3.4.4. ABATEMENT COST FUNCTION	3-19
3.5	CARTRIDGE DISPOSAL OPTIONS - PETROLEUM SOLVENT PLANTS	3-21
	3.5.1. OFF-SITE DISPOSAL AND TREATMENT OF STILL BOTTOMS AND FILTER MUCKS	3-21
	3.5.2. OFF-SITE TREATMENT AND DISPOSAL OF CARTRIDGES	3-27
	3.5.3. ABATEMENT COST FUNCTION	3-33
3.6	CONCLUSIONS	
PART 4 - CONCLUSIONS AND RECOMMENDATIONS		4-1
PART 5 - REFERENCES		5-1

:

TABLE OF CONTENTS Cont'd

PAGE

PART 6 - CONTACTS

6.1 ACKNOWLEDGEMENT 6-1
6.2 CONTACT ADDRESSES AND PHONE NUMBERS 6-1

APPENDIX A CURRENT WASTE PRODUCTION AND MANAGEMENT IN THE DRY CLEANING INDUSTRY
APPENDIX B DESCRIPTIONS OF TECHNOLOGIES FOR REDUCING THE SOLVENT CONTENT OF DRY CLEANING WASTES
APPENDIX C EXISTING WASTE MANAGEMENT SYSTEMS SERVING THE DRY CLEANING INDUSTRY
APPENDIX D REGULATORY CONSIDERATIONS

TABLE 2-1 List of Components and Waste Management Options 2-3
TABLE 2-2 List of Treatment Technologies 2-6
TABLE 2-3 Available Performance Data on On-Site Solvent Reduction Technologies 2-8
TABLE 2-4 Available Performance Data on Off-Site Solvent Reduction Technologies 2-10
TABLE 2-5 Technology Rating Criteria 2-13
TABLE 2-6 Ratings of Effectiveness of Technologies 2-14
TABLE 2-7 On-Site/Off-Site Treatment Advantages & Disadvantages 2-17

TABLE 3-1 Economics of Typical Dry Cleaning Plants that use Perchloroethylene 3-3
TABLE 3-2 Costs of Off-Site Treatment of Still Bottoms - Perchloroethylene Plants 3-7
TABLE 3-3 Costs of Off-Site Treatment of Cartridges - Perchloroethylene Plants 3-11
TABLE 3-4 Costs of Off-Site Disposal of Cartridges - Perchloroethylene Plants 3-14
TABLE 3-5 On-Site and Off-Site Treatment of Cartridges - Perchloroethylene Plants 3-17
TABLE 3-6 Costs of Off-Site Disposal of Still Bottoms and Filter Mucks - Petroleum Solvent Plants 3-22
TABLE 3-7 Costs of Off-Site Treatment of Still Bottoms - Petroleum Solvent Plants 3-25
TABLE 3-8 Costs of Off-Site Treatment of Cartridges - Petroleum Solvent Plants 3-28
TABLE 3-9 Costs of Off-Site Disposal of Cartridges - Petroleum Solvent Plants 3-31

TABLE OF CONTENTS Cont'd

PAGE

TABLE A-1 Annual Solvent Usage and Waste Generation A-1
TABLE A-2 Annual Solvent Losses in Waste Generated by Type of Waste A-2
TABLE A-3 Annual Solvent Losses in Waste Generated by Disposal Practice A-3
TABLE D-1 Perc Losses to Wastewater D-2
TABLE D-2 Perc Transport -- Air Emissions D-4
TABLE D-3 Monitoring of Dry Cleaning Establishments D-6

FIGURE 2-1 Waste Management Options 2-2
FIGURE 3-1 Abatement Cost Function for Off-Site Treatment of Used Cartridges 3-20

PART 1 BACKGROUND

The Ministry recently commissioned a survey of waste management practices in the Ontario dry cleaning industry[1]. Among the results of that survey was the revelation that some categories of wastes are currently being mismanaged. As a result of this mismanagement, significant quantities of Schedule 1 (Regulation 309) wastes are being disposed of in non-hazardous landfill sites.[1]

To address this concern, the Ministry has commissioned the present study on improved management of dry cleaning industry wastes. The purposes of this assignment were to:

- Identify, detail, and evaluate the technological options currently available to manage dry cleaning industry wastes, and

- Develop an economic assessment of waste management options in the dry cleaning industry.

The dry cleaning process is similar to the conventional laundering process but employs organic solvents rather than detergent and water. The principal steps in the process are also similar:

- one or more washes with solvent
- extraction of solvent by spinning (centrifugal extraction)
- drying by tumbling in an airstream (hot air stripping)

The predominant solvent used in the industry is perchlorethylene (Perc) with petroleum solvents (similar to kerosene) gradually losing acceptance[1-4]. Freons are not widely used and are expected to be discontinued shortly.

There are differences in dry cleaning processes attributable to the types of solvents used. This is largely due to the following factors:

- Perc is much more expensive than petroleum solvents
- Perc is non-flammable, while petroleum solvents are highly flammable
- The density of Perc is about twice that of petroleum solvents (for example petroleum solvents will float on water, water will float on Perc)[3-5].

The processes fall into three main categories:[1, 3-5]

- **Transfer Technology**. Here, the clothing must be transferred from the washer to the dryer.

- **Dry-to-Dry**. In this process, the washing and drying occur in the same machine. In drying, ambient air is heated and solvent-laden exhaust either vents to atmosphere or traverses a secondary recovery unit (cabinet/sniffer).

- **Fully-enclosed Technology**. This is similar to the Dry-to-Dry process except that ambient air is not used and vented, but rather solvent-laden air inside the unit is cooled to condense the solvent for re-use. Most units now sold operate on this process principle.

Washing of clothing, by its nature, will transfer contaminants from the clothing to the solvent. These contaminants can include fibre (lint), particles, oils and fats, dyes, odours, and other substances[6].

Economical reuse of contaminated solvent dictates that periodic clean-up of the solvent occur. Most dry cleaning processes employ continuous recirculation of solvent through some form of clean-up system and/or a periodic batch clean-up stage.[1]

Removal of solids is accomplished through filtration (paper, diatomaceous earth). Removal of dissolved or dispersed liquid contaminants is accomplished through activated carbon filtration and/or distillation. Cartridge filters are available which utilize paper only, paper and carbon, or carbon only (other materials are also found in combination). Distillation units for perc recovery generally operate under conditions of heating and possibly azeotroping with water. Due to solvent flammability, petroleum solvent distillation units generally operate under vacuum.[1,3,4,7,8]

A clean-up system will eventually become saturated or otherwise spent. Some solvent recovery may be possible from the clean-up system wastes but ultimately wastes will be generated.

The main waste categories identified in the dry cleaning industry are[1]:

- **Still Bottom Sludge.** This is the residue left from distilling the solvent away from the contaminants. This (liquid) residue contains the various contaminants (fats, oils etc.) and the solvent additives (detergents, dispersants, etc.)

- **Filter Muck.** This is the spent, solvent-laden diatomaceous earth filter-aid used by some dry cleaners. It ranges from a wet solid to a slurry in consistency.

- **Filter Cartridges.** These are generally the paper, paper-carbon, and carbon type. They are perforated metal canisters containing the media. Most of the solvent contained in spent cartridges is found in the carbon component.

Of th various permutations and combination of solvents used, and wastes generated, by the industry it has been estimated[1] that by far the most significant waste management problem is the disposal of perchloroethylene cartridges in non-hazardous landfill. Experience in other jurisdictions suggests that this poses a significant threat to ground water quality - necessitating a ban on such disposal.[1,9,11]

A detailed breakdown of waste production in the dry cleaning industry is provided in Appendix A. This is a retabulation of information provided in the previous study.[1] Information is aggregated according to three sizes of operations as defined in that report:

- **Small** - Less than 3,000 Kg of dry cleaning processed per month
- **Medium** - From 3,000 to 7,500 Kg of dry cleaning processed per month
- **Large** - More than 7,500 Kg of dry cleaning processed per month

The present study utilizes the above industry size classifications and waste quantity information.

PART 2 WASTE MANAGEMENT OPTIONS

2.1 INTRODUCTION

The present study seeks to explore waste management options for minimizing the amounts of solvents entering the environment via unsecure landfills (i.e. groundwater contamination).

Focusing on the solvent component of these wastes, waste management options can be described in the form of a flow-sheet (Figure 2-1).

Solvent content can be reduced in the wastes (i.e. the wastes can be managed) either on-site or off-site of each dry cleaning establishment. In the on-site case both controlled or uncontrolled processes can achieve solvent reductions. Controlled processes can form part of a solvent recovery and reuse system. In the off-site case wastes can be disposed of (hazardous waste landfill, non-hazardous landfill (status quo), incineration), or recovery processes can be applied. Recovered products would not necessarily be limited to solvent alone but could include other waste constituents.[6]

It should be noted that, by the law of diminishing returns, all paths will lead to a waste. The question however is one of "waste quality" (i.e. contaminant minimization).

2.2 WASTE COMPONENTS AND MANAGEMENT OPTIONS

The following list (Table 2-1) describes management options of the primary wastes along with potential "products" of treatment/recovery of these wastes. "Primary wastes" refers to dry cleaning wastes produced from the dry cleaning process,to distinguish from products/ wastes/residues resulting from treatment of the "primary wastes".

FIGURE 2-1

WASTE MANAGEMENT OPTIONS

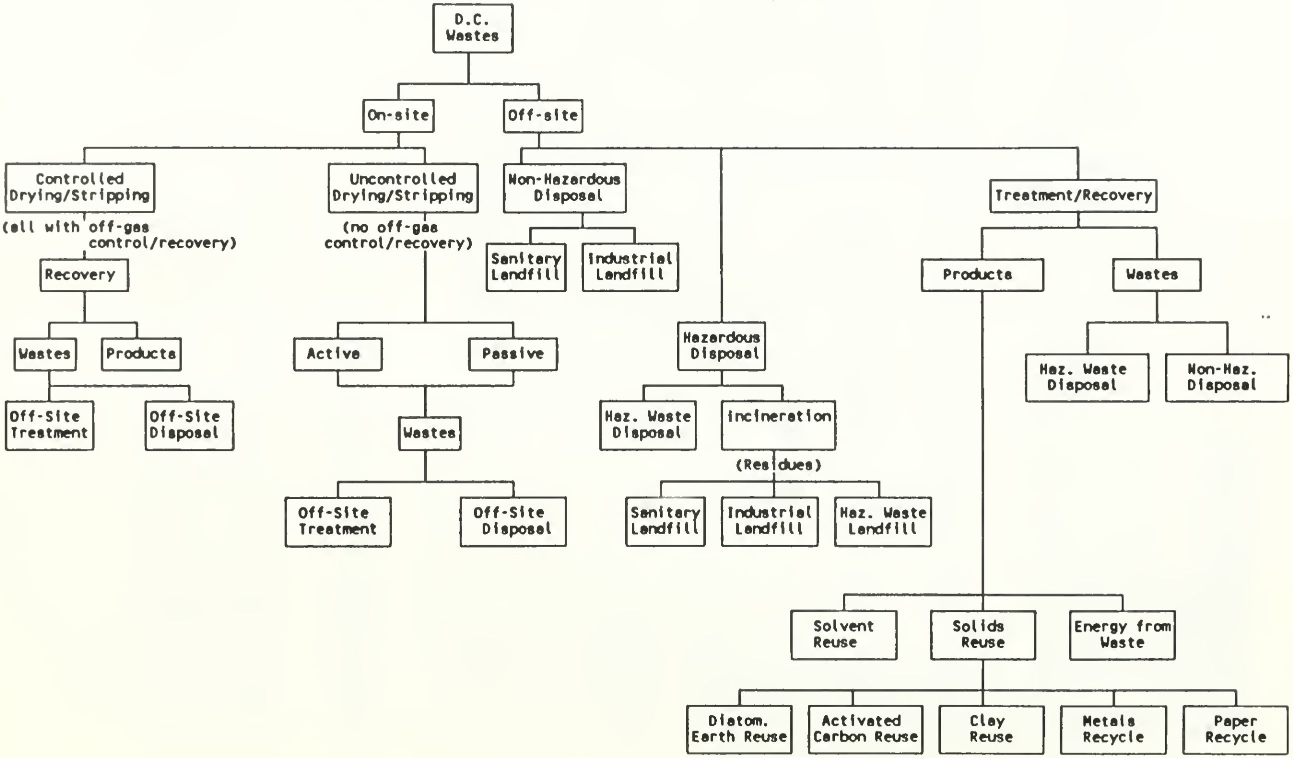


TABLE 2-1

LIST OF COMPONENTS AND WASTE MANAGEMENT OPTIONS

Primary Wastes	
Cartridges, Mucks, Still Bottoms	o Treatment - On site - Off-site o Disposal - Hazardous Waste Landfill - Municipal/Sanitary Landfill o Incineration o Sanitary Sewer (Mobile Mucks and Still Bottoms only).
Treatment Products/ Wastes/Residues[6,9]	
Solvent	o Reuse for Dry Cleaning o De-greaser or other Technical Grade Solvent applications o Raw material/Feedstock - other compounds
Oils/Fats/Waxes	o Fuel oil supplement (BTU Recovery) o Raw material/Feedstock - other compounds
Activated Carbon	o Regeneration & Reuse o Pigment Applications o Incineration o Landfill
Diatomaceous Earth	o Cleanup & Reuse for Filtration (e.g. Kieselgur processes)[12] o Incineration & Landfill (high ash content - silica)
Clay	o Cement Kiln Feedstock o Incineration & Landfill
Paper	o Recycle o Incineration o Landfill
Metal	o Sort & Recycle o Landfill

As can be seen, dry cleaning wastes can contain many potentially useful products. While reuse of all such products makes environmental sense, there may be technological, logistical, and/or economic obstacles to overcome which may make full reuse infeasible. This is explored further in the following sections.

2.3 TREATMENT TECHNOLOGIES

To treat a waste means to do something to it. In terms of the goal of solvent minimization in wastes ultimately destined for landfill, relevant methods or technologies must actually reduce the amount of solvent in wastes.

To identify what technologies might be applied to solvent minimization, the following approach was taken:

- A thorough search of current literature was undertaken via on-line database services. Citations and abstracts were reviewed and relevant publications ordered for review.

- Industry sources were contacted and information obtained through meetings, telephone conversations and written communications. Sources included U.S. and Canadian dry cleaning associations, equipment/service suppliers, and individual dry cleaning establishment operators/owners.

- Government sources were contacted and information obtained through meetings, telephone conversations, and written correspondence.

- In-house knowledge and expertise was applied to "what else" could be done to reduce solvent content in wastes.

The following list (Table 2-2) summarizes the results of our investigation. Treatment technologies (on-site and off-site) have been grouped according to principle and then broken down into individual process variants. One category, "Handyman" techniques, represents a collection of techniques for utilizing stages of the existing dry cleaning process for a waste minimization application for which it was not necessarily designed.

For a description of each technology, refer to Appendix B.

2.4 TECHNOLOGY PERFORMANCE DATA

The operating efficiency of each technology in reducing the solvent content of a waste can be highly variable due to factors which can include:[1-8]

- A process which is useful for one waste type may not be satisfactory for another type. For example vacuum distillation may be effective for still bottoms but be largely not applicable to activated carbon cartridges.
- A piece of equipment from manufacturer 'A' may not perform as well as a similar piece of equipment from manufacturer 'B'.
- Variable waste (feedstock) composition or quantity may yield variable solvent reduction (product).

TABLE 2-2

LIST OF TREATMENT TECHNOLOGIES

Active

- DISTILLATION
  - Sparging
  - Conventional
    - Muck cooker
    - Oil cooker
  - Vacuum
  - Sniffer/Cabinet
    - Hot Air
    - Forced Air, Room Temp.
  - Azeotroping
    - Steam sweep/injection
    - Water added

- EXTRACTION
  - Vacuum Press (Mucks and Heavy Still Bottoms)
  - Solvent
  - Electrolytic/catalytic decomposition

- "HANDYMAN"
  - Cartridges
    - In housing
    - In lint-trap
    - In tumbler (drier) units
    - In distillation units (non-sparge)
    - Oven-bake
    - Pressure-liquid wash
    - Centrifugal drain

- INCINERATION
  - Thermal
  - Catalytic

Passive

- GRAVITY DRAIN

- AIR DRY

- SUN BAKE

* For a description of each technology, refer to Appendix B.

- Operator skill (or lack of) may lead to variable results. Intermittent, batch operation may contribute to this problem.
- The maintenance history of a piece of equipment may determine its performance more than its design.

Since the goal of a treatment technology is reduction of solvent content to a minimal absolute amount in the waste, technology performance is best described as the lowest achievable level of solvent in the waste.

Table 2-3 presents the available performance data pertaining to on-site solvent content reduction technologies. Information is sorted by waste type and solvent type. Note that "n/a" refers to a technology not suitable (e.g. incompatible) for a specific type of waste or solvent. Numbers listed are in % solvent per weight of total waste. Where ranges are listed, the low end generally refers to operation of the technology under laboratory conditions, while the high end represents more typical operation in a dry cleaning plant. Note also that a technology applied off-site in a large central facility would achieve or better the low end of each range[2, 6-9]. Table 2-4 presents the off-site performance data. Dashes represent insufficient or unavailable performance data.

Information sources for the above included the International Fabricare Institute (IFI)[8, 13-16], the Dry Cleaners and Launderers Institute (DCLI)[2], the Beak report[1] and supplier and operator contacts.[6, 7, 17]

The wide ranges in some sets of performance data may be difficult to accept on first pass. However, as was pointed out in the previous study, by every single industry contact made, and several EPA publications - extreme variances in solvent mileage are found throughout the industry[1-9, 17]. Solvent mileage (i.e. the number

TABLE 2-3

Available Performance Data on On-Site Solvent Reduction Technologies

TECHNOLOGY		TYPES OF WASTE					
		Still Bottom Sludges		Filter Mucks		Cartridges	
		PERC[A]	PET[B]	PERC	PET	PERC	PET
DISTILLATION	- Sparging[1,7,8,15,16]	n/a	n/a	n/a	n/a	0.2-16[C,D]	n/a[E]
	- Conventional[1, 8, 14]	55-60	n/a	n/a	n/a	n/a	n/a
	- Muck cooker	---[F]	n/a	25-50	n/a	n/a	n/a
	- Oil cooker	---	n/a	n/a	n/a	n/a	n/a
	- Vacuum	---	---	---	---	---	---
	- Sniffer/Cabinet[1,19]						
	- Hot air	n/a	n/a	n/a	n/a	7	n/a
	- Forced room temp. air	n/a	n/a	n/a	n/a	5-42	---
	- Azeotroping[1,8, 13-16]						
	- Steam sweep/injection	1-3	n/a	25	n/a	0.2-16	n/a
	- Water added	0.4-16	n/a	1-3	n/a	0.2-16	n/a
EXTRACTION	- Vacuum Press	n/a	n/a	---	---	n/a	n/a
	- Solvent	---	---	---	---	---	---
	- Electrolytic/catalytic decomposition	---	---	n/a	n/a	---	---
"HANDYMAN"[1,2,8]	In Housing	n/a	n/a	n/a	n/a	3-4	n/a
	- In lint-trap	n/a	n/a	n/a	n/a	5	n/a
	- In tumbler	n/a	n/a	n/a	n/a	35	n/a
	- In still	n/a	n/a	n/a	n/a	2-20	n/a

TABLE 2-3 Cont'd

TECHNOLOGY	TYPES OF WASTE					
	Still Bottom Sludges		Filter Mucks		Cartridges	
	PERC	PET	PERC	PET	PERC	PET
"HANDYMAN" Cont'd - Oven-bake	n/a	n/a	---	n/a	---	n/a
- Pressure-liquid wash	n/a	n/a	n/a	n/a	---	---
- Centrifugal drain	n/a	n/a	---	---	---	---
INCINERATION - Thermal	---	---	---	---	---	---
- Catalytic	---	---	---	---	n/a	n/a
GRAVITY DRAIN[1,7,17]	n/a	n/a	---	---	17-47	---
AIR DRY	n/a	n/a	---	---	---	---
SUN BAKE	n/a	n/a	---	---	---	---

NOTES:

A PERC - Perchloroethylene
B PET - Petroleum solvent
C All values are estimated % solvent in wastes after treatment.
D Lower values in ranges are generally under lab conditions, higher values under typical field conditions.
E n/a means technology not applicable to type of waste or solvent.
F Blank fields (---) indicate no estimated data available.
G Note that data presented in this table originates from different sources, and largely under unknown operating conditions.

TABLE 2-4

Available Performance Data on Off-Site Solvent Reduction Technologies

TECHNOLOGY	TYPES OF WASTE					
	Still Bottom Sludges		Filter Mucks		Cartridges	
	PERC[A]	PET[B]	PERC	PET	PERC	PET
DISTILLATION						
- Conventional	---	---	---	---	---	---[G]
- Vacuum/Azeotroping[D,6]	<0.1[C]	<0.1	<0.1	<0.1	<0.1	<0.1
- Steam stripping[D,6]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
INCINERATION						
- Thermal[E]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
- Catalytic[F]	n/a	n/a	n/a	n/a	n/a	n/a[H]

NOTES:

A. PERC - Perchloroethylene
B. PET - Petroleum Solvent
C. All values are estimated % solvent after treatment
D. Based on data provided and assuming 50% solvent content on feed wastes.
E. Based on Monenco in-house information re: rotary kiln & fluidized bed incineration
F. n/a based on consistency not expected to be compatible
G. -- data unavailable
H. n/a - not applicable to waste type

of lbs. of dry cleaning processed per gallon of solvent) relates directly and significantly to the profit margin of each dry cleaning establishment. Poor solvent mileage has been attributed to inadequate equipment maintenance, inefficient operating practices, and unskilled process operation.[1-9, 17]

Add-on solvent reduction (i.e. pollution control) equipment would thus not be expected to perform in an average plant as well as in a test laboratory.

2.5 EVALUATION OF TECHNOLOGIES

The purpose of the subject technologies is the reduction of solvent content in wastes ultimately destined for landfill. The best technologies then are those that can reduce the solvent content as low as possible.

In assessing "performance" it is not sufficient to look at just the effectiveness of the design principle or how well it performs when operated in a test lab by a chemist or engineer. Of prime importance is how well a technology can be expected to perform in actual field (plant) use. Also, the overall prognosis for long term performance must be considered. For example a new, emerging technology may be in the prototype stage (i.e. a lot of "bugs" to discover and work out). Also, a technology may be well established elsewhere (e.g. Europe) but have no local infrastructure of support for parts, maintenance, and operation.

Consequently, evaluation criteria have been developed to describe the "effectiveness" of the technologies based on estimated performance in theory, in practice, and in the long term.

Regarding "design effectiveness", a figure of ≤1% solvent content after treatment has been used as a most desirable goal, a figure of ≤10% solvent content as a desirable goal, and >10% solvent content as less desirable.

In terms of "performance in use" a time/frequency consideration has been added to design performance. For example under the most desirable category would be those technologies which can, in the plant, achieve ≤1% solvent content, 90% of the time. In the least desirable category would be those technologies which could not deliver ≤10% solvent content, 75% of the time.

For the long term prognosis, "establishment and support" has been assessed.

Table 2-5 lists and describes the criteria for detailed ratings of effectiveness.

Table 2-6 lists the actual ratings scores given each technology by the study team. The higher, the total score, the more effective the technology is likely to be in achieving solvent reduction.

A higher rating means that the technology will be more "effective". It addresses the questions: how well?, how often?, and for how long? will the technology be able to reduce solvent contents in wastes.

TABLE 2-5

Technology Evaluation Criteria
Ratings of Effectiveness*

1. Design Effectiveness

Can the technology actually or in theory reduce solvent contents in wastes destined for non-hazardous landfill?

Rating	Description
5	Solvent content can be brought down to ≤1% w/w.
2	Solvent content can be brought down to ≤10% w/w.
0	Can not bring solvent content down to ≤10% or data not available

2. Performance in Use

In actual plant use can it or is it likely to reduce solvent contents in wastes destined for non-hazardous landfill? How sensitive to user variables (e.g. training, skill, attention, maintenance) is it?

Rating	Description
5	Can achieve solvent content in residues of ≤1%, 90% of the time (i.e. is independent of user variables.)
2	Can achieve solvent content in residues of ≤10%, 75% of the time (i.e. is essentially independent of user variables
0	Cannot achieve solvent content of ≤10%, 75% of the time (i.e. is highly dependent on user variables)

3. Establishment and Support

Is the technology well established? Will service, parts, support etc. be likely to be available over the long term to enable continued operation?

Rating	Description
2	Principle is well established. Suppliers well established in North America.
1	Principle well established; North American suppliers not yet established.
0	Principle not yet established.

---

* See Tables 2-3 and 2-4 for performance data on each technology.

TABLE 2-6

Ratings of Effectiveness of Technologies

Technology/ System	Design Effectiveness	Performance In Use	Establishment and Support	Total
ON-SITE				
DISTILLATION				
- Sparging	5	0	2	7
- Conventional	0	0	2	2
- Muck cooker	0	0	2	2
- Oil cooker	2	0	2	4
- Vacuum	0	0	1	1
- Sniffer/Cabinet				
- Hot air	2	0	2	4
- Forced room temp. air	2	0	2	4
- Azeotroping				
- Steam sweep/ injection	5	0	0	5
- Water added	5	0	0	5
EXTRACTION				
- Vacuum press	0	0	2	2
- Solvent	0	0	0	
- Electrolytic/ catalytic decomposition	0	0	0	
"HANDYMAN"				
- In housing	2	0	0	2
- In lint Trap	2	0	0	2
- In tumbler	0	0	0	
- In still	2	0	0	2
- Oven-bake	0	0	0	
- Pressure-liquid wash	0	0	0	
- Centrifugal drain	0	0	0	
GRAVITY DRAIN	0	0	0	
AIR DRY	0	0	0	
SUN BAKE	0	0	0	

TABLE 2-6 Cont'd

Technology/ System	Design Effectiveness	Performance In Use	Establishment and Support	Total
OFF-SITE				
DISTILLATION				
- Conventional	0	0	2	2
- Vacuum azeotroping	5	5	2	12
- Steam stripping	5	5	2	12
INCINERATION				
- Thermal	5	5	2	12
- Catalytic*	2	2	1	5

* Note that the consistency of the wastes dictates the limitations here. In addition highly chlorinated compounds are problematic.

2.6 ON-SITE VS. OFF-SITE TREATMENT

All available data point to the judgement that adequate performance of on-site treatment technologies cannot be assured. Predictions of relative long-term performance can also be made by considering how well the dry cleaning processes perform in use. Solvent mileage is an indicator. There is a large economic incentive for high solvent mileage. However, extremely variable solvent mileage is found from establishment to establishment. It is the opinion of several sources that industry solvent mileage can be doubled with virtually no cost (through attentive operation, and minimal maintenance)[1-9, 17]. The continuing poor solvent mileage in the industry does not bode well for the prospect of good operation of a pollution control device.

Only the few dry cleaning operations that achieve good solvent mileage, or are already involved in one or more treatment technologies, can be expected to effectively operate on-site treatment technologies.[2, 7, 17] The large majority of dry cleaning operations, however, cannot be expected to operate an on-site treatment technology to consistently achieve less than 1-10% solvent content in their wastes. This inability to assure performance would not only impact environmentally but would also adversely impact the cost-recovery (due to recovered solvent) and thus economic viability of the technology.

Table 2-7 lists the advantages and disadvantages of on-site and off-site treatment. Regulatory considerations are mentioned and are discussed in further detail in Appendix D.

Of particular concern to the dry cleaning industry is that, if off-site alternatives are preferred, no single company should have a monopoly on waste management (i.e. that there be competition).[2,7,17]

TABLE 2-7

ON-SITE/OFF-SITE TREATMENT

ADVANTAGES & DISADVANTAGES

	ADVANTAGES	DISADVANTAGES
ON-SITE	o Recovered solvent can be reused. o Some possible operating economic advantage. o Incentive for development and installation of more efficient Dry Cleaning processes. o Philosophical - i.e. the user plays a more active role in waste management	o High variability in performance due to unskilled operators or inadequate maintenance. Performance cannot be assured. o High capital investment by industry. o Replication of services (each of 1200 plants). o Operating inefficiencies due to small quantities. o Regulatory monitoring nightmare. o Particularly disadvantageous to small operations. o More opportunity for other environmental impacts. o Hazardous wastes will still be generated for off-site treatment/disposal
OFF-SITE	o More efficeint operations due to scale. o More easily monitored. o Best technologies easier to mandate. o More opportunity for recycle, recovery, reuse. o More likelihood of recovery of more components of waste. o Final wastes more easily and legally managed. o No on-site capital investment at each dry cleaning establishment. o Lower on-site operating costs and headaches at each dry cleaning establishment. o More readily administered from a regulatory standpoint	o Transportation costs & risks. o Service costs (regular). o Possibility of "hostage industry" if few off-site operations available. o Some limitations of current regulations could inhibit start ups (e.g. transfer station approvals for off-site bulking, licensed hauler provisions).

About seven years ago, in response to problems in dealing with still bottoms, one supplier of dry cleaning equipment and supplies established an off-site waste management system[2,7].

Industry contacts have expressed the opinion that, in consideration of logistics, economics, and regulatory issues, implementing off-site treatment/recovery of wastes would not adversely affect the profitability of most dry cleaners.[2,5,7,9,17] Some dry cleaners may have the 'wherewithal' to operate a treatment technology efficiently (technically and economically). The relatively few dry cleaners who would prefer to do this would not adversely impact the waste volumes required to permit profitable off-site treatment facilities to exist.

In addition, there are potentially some emerging "off-shore" technologies which seem promising for on-site use.[17] Development could be encouraged through "4R's" program funding.

The overall logic in the debate over on-site vs. off-site treatment of wastes from the 1200 dry cleaning establishments in Ontario can be viewed through the analogy of consumers using glass bottles.

It makes more logistical, technical, and economic sense to have central plants which re-melt and reuse glass bottles than it does to have each consumer purchase a "home glass plant" to do this recovery. In addition, it is easier and more effective to control other emissions from a small number of large plants than from a large number of small plants.

PART 3 ECONOMIC ASSESSMENT OF THE MOST EFFECTIVE WASTE MANAGEMENT OPTIONS

3.1 INTRODUCTION

The preceeding sections discussed and reviewed individual technological options for the reduction of solvent content in wastes. Based on well defined criteria of effectiveness, very few options could consistently achieve solvent content of less than 1-10% in dry cleaning plant wastes. The "best" technologies are all "better" when applied off-site in larger central processing facilities. On-site treatment technologies cannot be expected to perform adequately on a consistent basis at present.

The off-site options for improved waste management in the dry cleaning industry assessed below are by far the most technically viable. Due to the fact that the largest current waste problem is mismanagement of filter cartridge wastes containing perchloroethylene, we have also included the most technically viable on-site cartridge treatment system ("sparging") in the following assessment. While on-site performance to acceptable levels of solvent content cannot be assured with this technology, including the best of the on-site technologies will illustrate the relative economics involved.

The most viable options to be further assessed then become:

- o On-Site Treatment - Sparging Units
- o Off-Site Treatment - Dry Cleaning Supplier Service
  - - Waste Management Company Service (Off-site treatment technologies would be:[7,9]
    - o Steam stripping and activated carbon regeneration for cartridge wastes.

o Vacuum (azeotroping) distillation for still bottoms and filter mucks)

- o Off-Site Disposal - Incineration
  - Secure (Hazardous Waste) Landfill

The difference between "Dry Cleaning Supplier" and "Waste Management Company" service relates to the waste transportation logistics (i.e., the Dry Cleaning Supplier goes out full and occasionally comes back full, whereas the Waste Management Company goes out empty and comes back full). The Dry Cleaning Supplier scenario is generally referred to as "product stewardship".

The following discussion explores the economics of implementing the above options in terms of a typical small, medium, and large dry cleaning establishment (as defined in Section 1.1). Detailed cost estimates are provided and projected impacts on the financial health of each prototype establishment are explored.

3.2 ECONOMICS OF TYPICAL PLANTS

First, we examine the economics of typical small, medium and large dry cleaning plants. This is done in Table 3-1. The sizes of the typical plants are as defined in Section 1.1. There is a significant variation in the revenue per kilogram of dry cleaning - \$6.00 to \$12.00 per kg. While the highest revenues (prices) tend to be found in the larger urban centres there is a significant variation in most areas. In other words, very few dry cleaners are charging maximum prices.

The operating profit is shown as a typical percentage of revenue and a dollar range. While the figures are all positive, (an average firm in each size category is profitable) not every dry cleaner in the province is profitable. Some dry cleaners in Ontario report

TABLE 3-1: ECONOMICS OF TYPICAL DRY CLEANING PLANTS THAT USE PERCHLOROETHYLENE

		SMALL	MEDIUM	LARGE
1)	Definition of Plant Size (kg of dry cleaning year)	<36,000	36,000 to 90,000	>90,000
2)	Average annual quantity of dry cleaning for plants that use perchlorethylene (kg)	21,500	62,500	161,500
3)	Total revenue \$6.00 to \$12.00/kg. Use \$9.00/kg ± 1/3	\$193,500± 1/3	\$562,500± 1/3	\$1,453,500± 1/3
4)	Production costs as % of revenue	60	60	60
5)	Sales, administration and other costs as % of revenue	28	28	33
6)	Operating profit as % of revenue	12	12	7
7)	Operating profit	\$22,500± 1/3	\$67,500± 1/3	\$100,000± 1/3

Sources and notes:

1) Definitions are from Beak 1987 page 4.7.

2) Calculated from Beak 1987, Table 4.6. The average reflects plants using the transfer, hot and refrigerated technologies. In the case of small plants the 59 that use perchloroethylene process 1,263,000 kg of dry cleaning per year for an average of 21,407 or 21,500 kg/year.

3) Revenue per kg of dry cleaning provided by confidential industry sources.

4) Production costs as a per cent of revenue provided by confidential industry sources.

5) Provided by confidential industry sources.

6) Provided by confidential industry sources.

7) Calculated using lines 3 and 6. For small plants annual revenues range between $129,000 and $258,000. Operating profits at 12% range between $15,480 and $30,960 or $15,000 to $30,000 when rounded.

losses. Some of those losses may be due to the manner in which the compensation of the owner/manager is structured or to other "accounting" factors. Losses may also reflect "real" causes such as high rent or financing costs or inefficient operation.

Other dry cleaners have higher profits than those shown, both on a percentage of revenue and an absolute dollar basis. The higher profits usually reflect good management. Although the actual ranges of profits are much wider, the figures shown are representative of the profits of average firms in the respective size categories.

The data shown relate only to the dry cleaning activities. Many dry cleaners also have laundry operations and some operate uniform or linen rental divisions. Those operations do not use perchloroethylene and so are excluded from the analysis. This ensures that the costs of waste disposal are related to the dry cleaning operations responsible for generating those wastes.

3.3 COST OF STILL BOTTOMS TREATMENT AND DISPOSAL

Most dry cleaning plants use a distillation unit to purify their perchloroethylene. The purified perchlorethylene is recovered for use and the impurities from the dry cleaning process collect as still bottoms.

About seven years ago a supplier of dry cleaning equipment and supplies established an off-site waste management system for still bottoms. Industry representatives cited this system as an efficient system for dealing with dry cleaning wastes at an affordable cost.[2] The costs of off-site treatment of still bottoms are therefore estimated for typical plant sizes as a basis for establishing what is considered affordable. Disposal of still bottoms is the major hazardous waste disposal cost currently incurred by dry cleaners.

Costs for off-site treatment of still bottoms for typical dry cleaning establishments are shown in Table 3-2. These costs represent less than 0.5 percent of the revenue of a typical plant or about 2.5 to 3.5 percent of the profits of a typical plant. This appears to have been affordable for the industry.

3.4 CARTRIDGE DISPOSAL OPTIONS - PERCHLOROETHYLENE PLANTS

As noted earlier, by far the most significant waste management problem currently faced by the dry cleaning industry is the disposal of perchloroethylene cartridges in non-hazardous landfill. Alternatives for treatment and disposal of used cartridges are as follows:

- on-site treatment - sparging units
- off-site treatment - supplier service
  - waste management company service
- off-site disposal - incineration
  - secure landfill.

The on-site treatment option has the benefit of recovering perchloroethylene from the used cartridges. However the perchloroethylene content of the used cartridges is still too high for non-hazardous landfill so they must be sent off-site for treatment or disposal.

The collection and off-site treatment of cartridges is most likely to be offered by Dalex (a supplier to dry cleaners) or Safety-Kleen (a waste management company). Dalex currently delivers supplies to

TABLE 3-2: COSTS OF OFF-SITE TREATMENT OF STILL BOTTOMS - PERCHLOROETHYLENE PLANTS

		SMALL	MEDIUM	LARGE
1)	Average annual quantity of dry cleaning for plants that use perchloroethylene (kg)	21,500	62,500	161,500
2)	Perchloroethylene use (litres/year)	1,660	10,700	8,875
3)	Cost of perchloroethylene ($2/litre)	$3,320	$21,400	$17,750
4)	Solvent mileage (litres/1000 kg of dry cleaning)	77	171	55
5)	Still bottoms produced (No. of 45 gal. drums)	2	4-6	10-15
6)	Charges for off-site treatment of still bottoms: $200 to $300/drum (including tax and transportation)	$ 400 to $ 600	$ 800 to $1,600	$2,000 to $3,500
7)	Still bottoms treatment costs as % of:			
	. Revenue	0.4%	0.3%	0.3%
	. Operating profit	2.7%	2.4%	3.5%

Sources and Notes:

1) From Table 3-1 line 2.

2) Calculated from Beak 1987, Table 4-6. The average reflects plants using the transfer, hot and refrigerated technologies. The 59 small plants use a total of 98,000 litres of perchloroethylene per year, for an average of 1,661 litres/year, rounded to 1,660 litres/year.

3) The cost of perchloroethylene was provided by Dalex and Filter Clean.

4) Calculated from lines 1 and 2 both of which are derived from data in Beak 1987, Table 4-6. In the case of small plants the calculation is 1,660 litres/21.5 1000 kg or 77 litres/1000 kg of drying cleaning.

5) Still bottoms produced are estimated on the basis of one 45 gal. drum per 13,500 to 15,000 kg of dry cleaning processed. This generation rate was derived from data provided by Dalex and drying cleaning plants.

6) The disposal cost of still bottoms was obtained from Dalex and dry cleaning plants. The cost includes transportation and sales tax. Prices are higher in northern Ontario than southern Ontario due, at least partly, to higher transportation charges, but transportation costs are not charged separately.

7) These figures are calculated using line 6 of Table 3-2 and lines 3 and 7 of Table 3-1. For example, disposal costs of $600 represent less than 0.4% of the annual revenues of $193,500 and about 2.7% of the $22,500 mid-point of the range of annual operating profits.

dry cleaners and collects still bottoms for off-site treatment. It could easily add collection and off-site treatment of used cartridges. The pricing structure is likely to be similar to that currently used for still bottoms -- a single all-inclusive price.

Safety-Kleen collects and treats wastes from service stations and similar establishments in Ontario. It also collects dry cleaning wastes in Quebec and the Maritimes. It could easily add collection of dry cleaning wastes to its current activities in Ontario. Its price structure for dry cleaning wastes involves a one-time registration fee, a low annual minimum and an additional, all-inclusive charge for each drum handled. Effectively the service is priced on a per drum basis.

Judging by Dalex' current charges for still bottoms, Safety-Kleen's current charges for dry cleaning wastes in Quebec and the Maritimes and the prices charged by other firms in the U.S., no difference can be predicted in the prices that would be charged based on the type of company offering the service.

To assess the economic implications of used cartridge treatment/disposal three cases must be considered:

- off-site treatment;
- off-site disposal in a secure landfill; and
- on-site treatment followed by off-site treatment.

These cases are analysed in turn.

3.4.1 Off-Site Treatment of Cartridges

The number of cartridges used annually by small, medium and large dry cleaners are shown in Table 3-3. The costs to the dry cleaners for off-site treatment are estimated to range between $12 and $20 per standard cartridge equivalent.

The collection and treatment services are priced with transportation costs and manifesting included. Thus the treatment cost of still bottoms (Table 3-2) and the treatment cost of cartridges (Table 3-3) both include transportation. The prices charged for these services in Northern Ontario are higher than those charged in Southern Ontario due, at least in part, to the higher transportation costs. But transportation charges are not billed separately in either case.

The costs of off-site treatment of used cartridges would be a little higher than the costs of disposal of still bottoms. The costs of off-site treatment of used cartridges would be approximately 0.4 percent of the revenue of a typical dry cleaning establishment. These costs would amount to 3.5 to 4.0 percent of the profits of small and medium plants and 6.5 percent of the profits of a typical large plant.

Using figures in the previous study (Beak, 1987, Table 4.6) for the number of establishments that use perchlorethylene we estimate the annual volume of used cartridges in Ontario to be as follows:

small: 59 plants x 43 cartridges = 2,537 cartridges
medium: 64 plants x 125 cartridges = 8,000 cartridges
large: 32 plants x 323 cartridges = 10,336 cartridges
20,873 cartridges

The figures should be interpreted as a range of roughly 15,000 to 25,000 cartridges per year.

TABLE 3-3: COSTS OF OFF-SITE TREATMENT OF CARTRIDGES - PERCHLOROETHYLENE PLANTS

		SMALL	MEDIUM	LARGE
1)	Average annual quantity of dry cleaning for plants that use perchloroethylene (kg)	21,500	62,500	161,500
2)	No of cartridges based on 500 kg cleaning/standard cartridge	43	125	323
3)	Cost of purchasing cartridges approx $25 to $35 per standard cartridge	$1,000 to $1,500	$3,200 to $4,500	$ 8,500 to $11,500
4)	Cost of disposal of cartridges $12 to $20 per standard cartridge	$ 500 to $ 850	$1,500 to $2,500	$3,800 to $6,500
5)	Estimated cartridge treatment costs as % of:			
	. Revenue	0.4%	0.4%	0.4%
	. Operating profit	3.8%	3.7%	6.5%

Sources and Notes:

1) From Table 3-1 line 2.

2) Data on cartridge use were provided by dry cleaners and Dalex. These were converted to 500 kg of dry cleaning per standard cartridge. Cartridges come in two sizes "standard" and "jumbo" with 1 jumbo cartridge being equivalent to 3 standard cartridges in terms of size and cleaning capacity.

3) Costs of cartridges were provided by Dalex and dry cleaners.

4) Costs of cartridge disposal based on prices quoted by Safety-Kleen and Filter Clean. The prices quoted include transportation to the treatment facility.

5) These figures are calculated using line 4 of Table 3-3 and lines 3 and 7 of Table 3-1. For example, disposal costs of $850 represent about 0.4% the annual revenues of $193,500 and about 3.8% of the $22,500 mid-point of the range of annual operating profits.

3.4.2 Off-Site Disposal

The costs of off-site disposal of used cartridges in secure landfill are estimated in Table 3-4. The number of cartridges used annually by each size of plant remains unchanged.

It is assumed that drums of used cartridges are collected by a registered waste hauler on a "milk run" basis because of the small quantities involved (1 drum/month for small plants). The costs of secure landfill are added to those of on-site inspection and testing and transportation.

The results obtained in Table 3-4 suggest that off-site disposal is roughly five times as costly as off-site treatment of cartridges. This reflects the fact that nearly all components of the used cartridges can be recycled, thus generating some revenue to help offset the treatment costs.

Off-site disposal of used cartridges would cost about 2.2 percent of revenue and almost 20 percent of profits for small and medium plants.

TABLE 3-4: COSTS OF OFF-SITE DISPOSAL OF CARTRIDGES - PERCHLOROETHYLENE PLANTS

		SMALL	MEDIUM	LARGE
1)	Average annual quantity of dry cleaning for plants that use perchloroethylene (kg)	21,500	62,500	161,500
2)	Number of cartridges used annually	43	125	323
3)	Number of drums of used cartridges generated annually	11	32	81
4)	On-site costs for driver and technician	$600	$1,750	$4,500
5)	Transportation costs	$500 to $1,500	$1,450 to $4,350	$3,600 to $11,000
6)	Costs for secure landfill	$2,200	$6,400	$16,200
7)	Estimated cartridge disposal costs	$3,300 to $4,300	$9,600 to $12,500	$24,300 to $31,700
8)	Estimated cartridge disposal costs as %			
	. Revenue	2.2%	2.2%	2.2%
	. Operating profit	19.1%	18.5%	31.7%

Sources and Notes:

1) From Table 3-1 line 2.

2) From Table 3-3 line 2.

3) Calculated on the basis of 4 standard cartridges per 45 gal. drum.

4) Based on data provided by Tricil. Estimated at one-half hour or $55 per drum.

5) Based on data provided by Tricil. Transportation charges for pick-up on a "milk run" basis range from $45 per drum in the Toronto area to $135 per drum west of Thunder Bay.

6) Based on data provided by Tricil. Assumes that the wastes do not need to be solidified prior to landfill.

7) Calculated as line 4 plus line 5 plus line 6.

8) Calculated from line 7 of Table 3-4 and lines 3 and 7 from Table 3-1.

3.4.3 On-Site Treatment

A sparging unit allows a dry cleaner to recover perchloroethylene from used cartridges. The perchloroethylene content of the used cartridges after sparging, assuming routine plant operation, is still too high for non-hazardous landfill. Hence, the used cartridges must still be sent off-site for treatment or disposal after sparging. As we have seen, off-site treatment is much less costly than off-site disposal, hence the former option is assumed to be chosen.

The economics of on-site treatment followed by off-site treatment of used cartridges is shown in Table 3-5. The sparging unit is clearly uneconomic for small plants. It is marginally uneconomic for a typical medium plant. In the case of a large plant a sparging unit would reduce the costs of treating used cartridges, but the payback may not be quick enough to be attractive to many operators.

Use of a sparging unit would reduce the costs of treatment of used cartridges to large dry cleaners to 0.3 percent of revenue and 4.4 percent of profits. These are comparable to the costs of off-site treatment alone for small and medium plants.

TABLE 3-5: ON-SITE AND OFF-SITE TREATMENT OF CARTRIDGES - PERCHLOROETHYLENE PLANTS

		SMALL	MEDIUM	LARGE
1)	Cost of a sparging unit	$5,500 (8 cartridges)	$5,500 (8 cartridges)	$9,200 (14 cartridges)
2)	Annual maintenance and financing costs (at 20% of capital cost)	$1,100	$1,100	$1,850
3)	Cost of an 8 hr stripping operation (with max. no. of cartridges)	$7-$16	$7-$16	$8-$18
4)	Total operating cost per year	$40-$100	$100-$250	$175-$425
5)	Saved expenditures from recovery of an average 4.55 litres of perchloroethylene per standard cartridge ($2.00/litre perc.)	$390	$1,125	$2,900
6)	Net annual savings (loss) after perchloroethylene recovery	($750-$810)	($75-$225)	$875-$625
7)	Cost of cartridge disposal at $12 to $20 per standard cartridge	$500-$850	$1,500-$2,500	$3,800-$6,500
8)	Net disposal costs including sparging savings	$1,250-$1,660	$1,575-$2,725	$2,925-$5,875
9)	Estimated costs as a % of:			
	. Revenue	0.9%	0.5%	0.3%
	. Operating profit	7.4%	4.0%	4.4%

Notes and Sources:

1) The cost of a sparging unit was provided by Dalex.

2) The capital cost is expressed as an annual cost, including maintenance, of 20% per year.

3) The cost of a stripping operation with a full load of cartridges is based on data provided by Dalex.

4) The total operating cost per year is calculated. The number of cartridges used per year is taken from line 2 of Table 3-3. This is divided by the capacity of the sparing unit and rounded up to get the number of stripping operations per year. e.g., 43 cartridges per year for small plants require 6 stripping operations of 8 cartridges each. The operating costs per stripping operation from line 3 are multiplied by the number of stripping operations and rounded e.g., 6 x $7 = 42, rounded to $40.

5) Data on perchloroethylene saved (1 gallon/standard cartridge) were provided by Dalex and Spic and Span Cleaners. The cost of perchloroethylene is taken from line 3 of Table 3-2.

6) Calculated as line 2 plus line 4 less line 5.

7) From line 4 of Table 3-3.

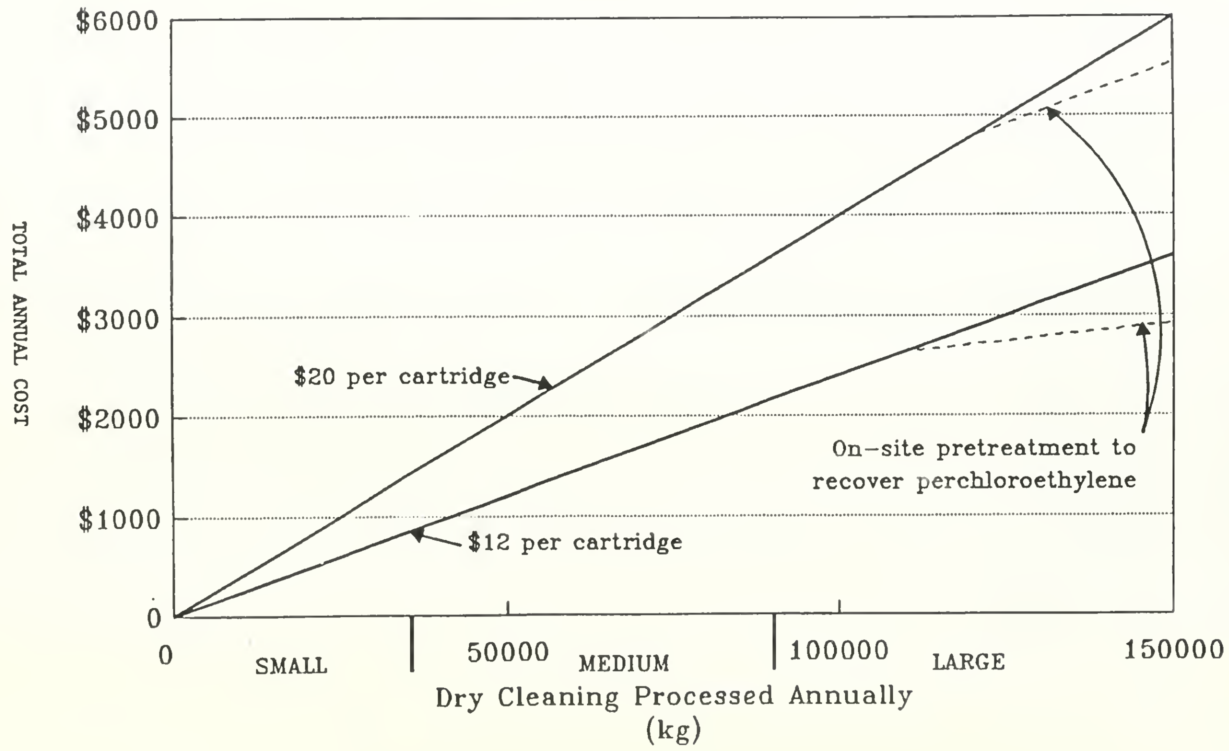
8) Calculated as line 7 less line 6.

9) These figures are calculated using line 8 of Table 3-5 and lines 3 and 7 of Table 3-1.

3.4.4 Abatement Cost-Function

An abatement cost function for off-site treatment of used cartridges is shown in Figure 3-1. The effects of on-site sparging of the used cartridges before shipment for off-site treatment is also shown. These functions reflect the calculations presented in Tables 3-3 and 3-5.

Figure 3-1: Abatement Cost Function for Off-site Treatment of Used Cartridges



3.5 CARTRIDGE DISPOSAL OPTIONS - PETROLEUM SOLVENT PLANTS

Approximately ten percent of the dry cleaning plants in Ontario use petroleum solvent rather than perchloroethylene, and this fraction is declining.[1] Because the numbers are much smaller and declining, the hazardous wastes from petroleum solvent plants are not analysed in the same depth as those from perchloroethylene plants.

The hazardous waste streams are the same; still bottoms and filter mucks and used cartridges. The off-site treatment and disposal options are the same as those for the perchloroethylene wastes. On-site treatment of used cartridges is not considered to be a realistic option for petroleum solvents due to the flammability of the solvent.

Off-site disposal and treatment of still bottoms and filter mucks are analysed first. Then the costs of off-site treatment and disposal of used cartridges are considered.

3.5.1 Off-site Disposal and Treatment of Still Bottoms and Filter Mucks

The costs of off-site disposal (incineration) of still bottoms and filter mucks are estimated in Table 3-6. The costs range from 0.3 to 0.6 percent of annual revenue and 2.5 to 5.0 percent of annual profits depending upon plant size.

TABLE 3-6: COSTS OF OFF-SITE DISPOSAL OF STILL BOTTOMS AND FILTER MUCKS - PETROLEUM SOLVENT PLANTS

		SMALL	MEDIUM	LARGE
1)	Definition of plant size of dry cleaning (kg/year)	<36,000	36,000 to 90,000	>90,000
2)	Average annual quantity of dry cleaning for plants that use petroleum solvent (kg)	12,500	67,500	710,000
3)	Average annual solvent use (litres/year)	4,200	18,750	265,000
4)	Average annual solvent use (kg/year)	3,150	14,050	198,750
5)	Still bottoms generated (kg/year)	100	450	6,350
6)	Filter mucks generated (kg/year)	40	185	2,600
7)	Still bottoms and filter muck generated (45 gal drums/year)	1-2	4-5	45-60
8)	On-site costs for driver and technician	$55-$110	$220-$275	$2500-$3300
9)	Transportation costs	$45-$270	$180-$675	$2000-$8100
10)	Cost of incineration	$145-$290	$580-$725	$6500-$8700
11)	Estimated costs of still bottoms and filter muck disposal	$245-$670	$980-$1675	$11,000-$20,100
12)	Estimated costs of still bottoms and filter muck disposal as % of:			
	. Revenue	0.6%	0.3%	0.3%
	. Operating profit	5.0%	2.5%	4.5%

Sources and notes:

1) Definitions are from Beak 1987 page 4-7.

2) Calculated from Beak 1987, Table 4-6.

3) Calculated from Beak 1987, Table 4-6.

4) Calculated from line 3 using a solvent density of 0.75 kg/litre (Beak 1987, Table 6-12).

5) Calculated as 3.2% of annual solvent use as shown in Beak 1987, Table 6-14.

6) Calculated as 1.3% of annual solvent use as shown in Beak 1987, Table 6-14.

7) Estimated on the basis of 150 to 225 kg per 45 gal. drum when full. Drums are not necessairly full when picked up on a milk run basis.

8) Based on data provided by Tricil. Estimated at one-half hour or $55 per drum.

9) Based on data provided by Tricil. Transportation charges for pick-up on a "milk run" basis range from $45 per drum in the Toronto area to $135 per drum west of Thunder Bay.

10) Based on data provided by Tricil. A cost of $145 per drum is used.

11) Calculated as the sum of lines 8, 9 and 10.

12) Calculated using line 11 and the calculated annual revenue and operating profit. Annual revenue is line 2 x $9/kg (from Table 3-1) and operating profit is 12% or 7% of annual revenue (from Table 3-1).

The costs of off-site treatment of still bottoms and filter mucks are estimated in Table 3-7. The costs of treatment are roughly 50-60 percent of the costs of disposal for still bottoms and filter mucks. The costs of off-site treatment of petroleum solvent still bottoms are lower than those of treating perchloroethylene still bottoms because the former can be used as a fuel in the waste treatment facility.

TABLE 3-7: COSTS OF OFF-SITE TREATMENT OF STILL BOTTOMS - PETROLEUM SOLVENT PLANTS

		SMALL	MEDIUM	LARGE
1)	Average annual quantity of dry cleaning for plants that use petroleum solvent (kg)	12,500	67,500	710,000
2)	Still bottoms and filter muck produced (No of 45 gal. drums)	1-2	4-5	45-60
3)	Charges for off-site treatment of still bottoms and filter muck $125 to $200/drum (including tax and transportation)	$125 to $400	$500 to $1,000	$5,600 to $12,000
4)	Still bottoms treatment costs as % of:			
	. Revenue	0.4%	0.2%	0.2%
	. Operating profit	3.0%	1.4%	2.7%

Sources and Notes:

1) Table 3-6 line 2.

2) Table 3-6, line 7.

3) Safety-Kleen provided data on charges for petroleum solvent still bottoms and filter mucks. The prices of $125 to $200 per 45 gal. drum are weighted averages. The prices are below those for perchloroethylene because the petroleum solvent still bottoms can be used as fuel in the waste treatment facility.

4) See Table 3-6, line 12.

3.5.2 Off-Site Treatment and Disposal of Cartridges

The costs of off-site treatment of used cartridges from petroleum solvent plants are estimated in Table 3-8. The costs are virtually identical to those for off-site treatment of used cartridges from perchloroethylene plants; roughly 0.4 percent of annual revenue and 3.5 to 6.5 percent of annual profits.

TABLE 3-8: COSTS OF OFF-SITE TREATMENT OF CARTRIDGES - PETROLEUM SOLVENT PLANTS

		SMALL	MEDIUM	LARGE
1)	Average annual quantity of dry cleaning for plants that use petroleum solvent (kg)	12,500	67,500	710,000
2)	No of cartridges based on 500 kg cleaning/standard cartridge	25	135	1420
3)	Cost of disposal of cartridges $12 to $20 per standard cartridge	$ 300 to $ 500	$1,600 to $2,700	$17,000 to $28,500
4)	Estimated cartridge treatment costs as % of:			
	. Revenue	0.4%	0.4%	0.4%
	. Operating profit	3.7%	3.7%	6.4%

Sources and Notes:

1) Table 3-6, line 2.

2) Calculated from line 1 and Table 3-3, line 2.

3) Safety-Kleen indicated that its charges for treatment of used cartridges from petroleum solvent plants would be the same as those for used cartridges from perchloroethylene plants.

4) See Table 3-6, line 12.

The estimated costs of off-site disposal of used cartridges are presented in Table 3-9. As was the case for used cartridges from perchloroethylene plants, disposal costs approximately five times as much as treatment. The off-site disposal costs are 2.0 to 2.5 percent of annual revenue or almost 20 percent of annual profit for small and medium plants.

TABLE 3-9: COSTS OF OFF-SITE DISPOSAL OF CARTRIDGES - PETROLEUM SOLVENT PLANTS

		SMALL	MEDIUM	LARGE
1)	Average annual quantity of dry cleaning for plants that use petroleum solvent (kg)	12,500	67,500	710,000
2)	Number of cartridges used annually	25	135	1420
3)	Number of drums of used cartridges generated annually	7	34	355
4)	On-site costs for driver and technician	$400	$1,900	$19,500
5)	Transportation costs	$300 to $ 900	$1,500 to $4,500	$16,000 to $48,000
6)	Costs for secure landfill	$1,400	$6,800	$71,000
7)	Estimated cartridge disposal costs	$2,100 to $2,700	$10,200 to $13,200	$106,500 to $138,500
8)	Estimated cartridge disposal costs as %			
	. Revenue	2.4%	2.2%	2.2%
	. Operating profit	20.0%	18.1%	31.0%

Sources and Notes:

1) Table 3-6, line 2.

2) Table 3-8, line 2.

3) Calculated on the basis of 4 standard cartridges per 45 gal. drum.

4) Based on $55 per drum. See Table 3-4, line 4.

5) Based on $45 to $135 per drum. See Table 3-4, line 5.

6) Based on $200 per drum. See Table 3-4, line 6.

7) Calculated as line 4 plus line 5 plus line 6.

8) See Table 3-6, line 12.

3.5.3 Abatement Cost Function

The abatement cost function presented in Figure 3-1 applies equally to off-site treatment of used cartridges from petroleum solvent plants. The on-site treatment portion of the curve does not apply to petroleum solvent plants.

3.6 CONCLUSIONS

Still bottoms and filter mucks are currently being collected for off-site treatment. The costs of this service are approximately 0.3 - 0.5 percent of the revenue or 2.5 - 3.5 percent of the operating profit of a typical dry cleaning plant. This system is considered by industry representatives to be operating well and at reasonable cost.

The lowest cost option available for dealing with used cartridges is off-site treatment. It would cost about 0.4 percent of the revenue or 2.5 to 6.5 percent of the operating profit of a typical dry cleaning plant.

In other words, the costs of handling used cartridges are slightly greater than those incurred at present to handle still bottoms. To put these costs in a different perspective, consider the price of dry cleaning a shirt. The price is in the range of $0.75 to $1.75. Even at the upper end of this range 0.4 percent of the revenue is less than 1 cent.

Given the wide range in revenue per kilogram of dry cleaning, the costs of off-site treatment of used cartridges could be passed on to consumers in the form of higher prices with little difficulty.

The added cost to the consumer (0.4%) will be so small as to have no measurable impact on the demand for dry cleaning services.

Firms already at the high end of the price range and who are nervous about their ability to pass on the cartridge treatment costs in the form of higher prices could probably achieve savings of similar magnitude through improvements in their operations (e.g., improved solvent mileage, better energy efficiency, etc).

All technologies evaluated involve complete treatment/disposal of 100% of the used cartridges. The cost effectiveness ranking is therefore simply the inverse of the cost. The lowest cost technology -- off-site treatment -- is the most cost-effective technology.

The potential for business closure and unemployment or employment creation in the dry cleaning industry is minimal. Off-site treatment and disposal of cartridges could create some employment in the waste treatment/disposal industry. If the off-site cartridge treatment service is operated by Safety-Kleen one or two jobs are likely to be created in Ontario. We expect that the cartridges would be processed at the company's existing facilities in northern Ohio. If the service is operated by Dalex it might result in employment for three to five people. Processing would be undertaken at the company's existing facilities in Concord. If the service is operated by a firm currently not active in Ontario it might create employment for seven or eight people.

PART 4 CONCLUSIONS AND RECOMMENDATIONS

- Through a ranking of the effectiveness of available treatment technologies, it has been concluded that consistent achievement of minimum solvent content in dry cleaning industry wastes can only be realized through off-site treatment. On-site treatment is more costly for small and medium plants and marginally less costly for large plants. Dry cleaners consulted indicated that they would be unlikely to invest in a sparging unit for the marginal cost savings achieved. They felt that they would have better uses for the capital.

- Off-site solvent recovery systems were found to be both technically and economically viable.

- Waste treatment via off-site solvent recovery systems would be expected to have negligible impact on the economic health of dry cleaning establishments.

- The estimated costs of cartridge disposal by this means would be less than 5 percent of profits, and less than 0.5 percent of revenue. They are higher, but not much higher, than the costs of similar disposal of still bottoms. Those costs have not created economic difficulties for dry cleaners.

- We believe that given the wide variation in revenue per kilogram, the cost could be passed on to the consumer with little difficulty (about 1¢ per shirt). Firms already at the high end of the price range could probably achieve savings equivalent to the cartridge disposal costs through improvements in their operations (e.g., improved solvent mileage, better energy efficiency etc.).

- In short, we believe that costs of cartridge disposal via off-site recovery systems are most likely to be passed on to consumers and to have negligible impact on the profitability of dry cleaning establishments. The added cost to the consumer will be so small as to have no measurable impact on the demand for dry cleaning services.

- In conclusion, off-site treatment can consistently and adequately reduce solvent levels in dry cleaning industry wastes without impacting on the financial health of the industry.

- In the implementation or enforcement of regulations affecting the dry cleaning industry we suggest that scheduling be staged to permit more than one reclamation operation to establish itself in Ontario. (The major dry cleaning industry concern is that a monopoly may become established). Encouragement may be provided through "4R's" program funding to reclamation operations interested in establishing in Ontario.

- Other jurisdictions have implemented an effective total ban on landfill disposal of any quantities of perchloroethylene wastes. This step appears to be justified in Ontario as well.

- Dry cleaners are small quantity generators. As such, allowing wastes to be accumulated on-site for extended periods of time would help relieve any burden of undue transportation costs from geographically remote parts of Ontario.

PART 5 REFERENCES

1. Beak Consultants, Robertson, J.L. and Salenieks, S.E., "Hazardous Waste Management Practices of the Ontario Dry Cleaning Industry", Ontario Ministry of the Environment, July 1987.

2. Dry Cleaners and Launderers Institute, Ontario (DCLI), Correspondence, 1989.

3. TRW Environmental Engineering Division, "Perchloroethylene Dry Cleaners: Background Information for Proposed Standards", EPA 450/3-79-029(a), August 1980.

4. U.S. Environmental Protection Agency, "Petroleum Dry Cleaners - Background Information for Proposed Standards and Promulgated Standards," EPA 450/3-82-012(a), November 1982, and EPA 450/3-82-012(b), September 1984.

5. Wolf, K. and C.W. Myers, "Hazardous Waste Management by Small Quantity Generators - Chlorinated Solvents in the Dry Cleaning Industry", Rand Corporation Report R-3505, 1987.

6. Filter Clean Inc., Correspondence and Literature, 1989.

7. Dalex Co. Ltd., Correspondence and Literature, 1989.

8. International Fabricare Institute (IFI), Correspondence, 1989.

9. Safety-Kleen Canada, Ltd., Correspondence and Literature, 1989.

10. Brodie, F.N., "Correspondence, August 1, 1989", Nova Scotia Department of the Environment, File 15-85-0034.

11. U.S. Environmental Protection Agency, Correspondence, 1989.

12. Zyla, Werner, "Kieselgur in Breweries and Dry Cleaning. Final Report. Recycling of Industrial Wastes (Phase II)," Dornier-System GMBH, Friedrichshafen, West Germany, Jul. 1977. (In German).

13. Andrasik, I., "Reducing Perc Content in Residues," IFI Bulletin T-560, 1987, 1983.

14. Busler, C., "Still Residue and Cooker Muck Update", Fabricare News, May 1984.

15. International Fabricare Institute, "Recovery of Perchloroethylene From Used Cartridges with the Puritan 4000 SRS Solvent Recovery System," No. F-40, May, 1987.

16. Meijer, J., "Reduction of Solvent Content in Cartridges", IFI Bulletin, T-568, 1985.

17. Spic and Span Cleaners, Correspondence, 1989.

18. Kelso, G.L. and T.W. Lapp, "Chemical Technology and Economics in Environmental Perspectives, Task IV - Activated Carbon", EPA 560/2-77-002, Feb. 1977.

19. Kleeberg, C.F., and J.G. Wright, "Control of Volatile Organic Emissions from Perchloroethylene Dry Cleaning Systems", EPA 450/2-78-050, Dec. 1978.

20. TRW Environmental Engineering Division, "Control of Volatile Organic Compound Emissions from Large Petroleum Dry Cleaners", EPA 450/3-82-009, September 1982.

21. Aimco - Solrec, Correspondence, 1989.

22. Tricil Ltd., Correspondence, 1989.

23. Lutz, S.J., "Environmental Regulations and Technology: The Dry Cleaning Industry", EPA 625/10-81-002, June 1981.

24. McCoy, B.C., "Study to Support New Source Performance Standards for the Dry Cleaning Industry", EPA 450/3-76-029, May 1976.

25. U.S. Government, "New Source Performance Standards", 40 CFR 60, Subpart JJJ, 1984.

26. Krasznai, J.P, and R.K. Cleary, "Distillation of Liquid Waste from the Freon-Based Dry Cleaning Process", Ontario Hydro Research Division Report K 85-330, 1985.

27. Ontario Research Foundation, Correspondence, 1989

28. Ontario Hydro, Correspondence, 1989.

29. Environment Canada, Correspondence, 1989.

30. Canadian Standards Association, Correspondence, 1989.

PART 6 CONTACTS

6.1 ACKNOWLEDGEMENT

The preparation of this report required the help of many people in many different organizations. The persons and organizations below were particularly helpful in providing information and we wish to thank them for their assistance.

Aimco - Solrec -- Laren Hesse
Dalex Co. Ltd. -- Nick Mazzoli, D'Arcy McConvey Jr.
Dry Cleaners and Launderers Institute -- Ken Adamson
Filter Clean, Inc. and Sun Belt Marketing & Development Company -- Allan Block, Gerry Burgmann, Donald Jeffares, Ronald Weisser
International Fabricare Institute -- John Meijer
Ontario Ministry of the Environment -- Gilles Castonguay
Safety-Kleen Canada Ltd. - Paul Kaulback, Scott McCurdy, Bob Smith
Spic and Span Cleaners -- Brian Kerr
Tricil Ltd. -- Jim Suddeby, Brent Scorfield
USEPA -- John Goodrich-Mahoney

6.2 CONTACT ADDRESSES AND PHONE NUMBERS

Except for a number of sources which provided information on the condition that they not be identified, the following is a list of available contact information.

Aimco - Solrec, Milton, Ontario 878-2627
Laren Hesse

Canadian Standards Association (CSA)
Rexdale Blvd.
Rexdale, Ontario
(416) 747-4000
Ahmed Husseini (416) 747-2697

Dalex Co. Ltd., 157 Adesso Drive
Concord, Ontario L4K 3C3
(416) 738-2070
D'Arcy McConvey, Jr., President
Nick Mazzoli, Chemical Sales Manager

Dry Cleaners and Launderes Institute,
49 Eglinton Ave. E.
Toronto, Ontario M4P 1G6
(416) 481-6881
Ken Adamson, President (416) 522-4651
Marcia Todd, Editor, Canadian Cleaner & Launderer (416) 825-2415

Environment Canada, (416) 973-1076
Graham Hartman

Filter Clean, Inc. and Sun Belt Marketing & Development Company,
Corporate Office
5015 S. Florida Ave.,
Suite 310
Lakeland, FL 33813
(813) 644-0757
Donald Jeffares, General Manager, FCI
Ronald Weisser, President SBM&D (813) 286-4033
Allan Block 705 Progress Ave., Unit 3B
Scarborough, Ont. M1H 2X1
(416) 438-3908
Gerry Burgmann (416) 491-2669

International Fabricare Institute,
12251 Tech Road
Silver Spring, Maryland 20904
(301) 622-1900
John Meijer, Research Chemist

Nova Scotia Department of the Environment,
P.O. Box 2107
Halifax, Nova Scotia B3J 3B7
F.N. Brodie, Environmental Engineer

Ontario Hydro, Research Division
Kipling Avenue, Toronto
(416) 231-4111
Terry Strack, ext. 6723
Steven Oda, ext. 6722

Ontario Ministry of the Environment
Waste Management Branch
40 St. Clair Avenue W.
5th Floor
Toronto, Ontario M4V 1P5
(416) 323-5214
Gilles Castonguay, Senior Engineer
Raj Khettry, Supervisor HWL/DU (416) 323-5226

Ontario Research Foundation (ORTECH)
Sheridan Park
Mississauga, Ontario
(416) 822-4111
Linda Varangu

Pegasus Ltd., P.O. Box 319
Agincourt, Ontario M1S 3B9
(416) 298-3141
Louis Jansurik

Safety-Kleen Canada Ltd.
101 Planchet Road
Unit 2
Concord, Ontario L4K 2C6
Paul Kaulback, Branch Manager (416) 665-9516
Scott McCurdy (416) 831-2261
Bob Smith, Hebron, Ohio

Spic and Span Cleaners
1764 Woodward Drive
Ottawa, Ontario K2C 0P8
(613) 727-1049
Brian Kerr, President

Tricil Ltd., Mississauga & Thorold (Niagara)
Jim Suddeby (416) 566-4322
Brent Scorfield 1-800-263-2432 (St. Catharines)

USEPA, (202) 382-4769
    Bob Scarberry
    John Goodrich - Mahoney
    Michelle Wilson, Section Head (202) 382-4770

APPENDIX A

CURRENT WASTE PRODUCTION AND MANAGEMENT IN THE DRY CLEANING INDUSTRY

TABLE A-1

ONTARIO DRY CLEANING INDUSTRY

ANNUAL SOLVENT USAGE AND WASTE GENERATION[1]

SIZE	PROCESS	NO. OF PLANTS	DRY CLEANING PRODUCTION (Kg)		SOLVENT USAGE (Kg)			SOLVENT IN WASTE (Kg)		
			Total	per Plant	Total	per Plant	per D.C.MT*	Total	per Plant	per D.C.MT
PERCHLOROETHYLENE		1,185	38,405,000	32,409	4,026,692	3,398	105	294,800	249	7.7
Small	Transfer	570	11,570,000	20,298	1,897,644	3,329	164	57,300	101	5.0
	Dry-to-Dry	352	11,915,000	33,849	761,944	2,165	64	42,200	120	3.5
	Fully-enclosed	28	485,000	17,321	22,960	820	47	5,900	211	12.2
		950	23,970,000	25,232	2,682,548	2,824	112	105,400	111	4.4
Medium	Transfer	110	5,180,000	47,091	739,640	6,724	143	99,900	908	19.3
	Dry-to-Dry	56	3,110,000	55,536	249,772	4,460	80	26,900	480	8.6
	Fully-enclosed	33	1,830,000	55,455	69,044	2,092	38	6,100	185	3.3
		199	10,120,000	50,854	1,058,456	5,319	105	132,900	668	13.1
Large	Transfer	17	2,540,000	149,412	158,096	9,300	62	14,800	871	5.8
	Dry-to-Dry	18	1,640,000	91,111	112,832	6,268	69	40,700	2,261	24.8
	Fully-enclosed	1	135,000	135,000	14,760	14,760	109	1,000	1,000	7.4
		36	4,315,000	119,861	285,688	7,936	66	56,500	1,569	13.1
PETROLEUM SOLVENT		131	3,765,300	28,743	1,240,800	9,472	330	78,100	596	20.7
Small	Transfer	105	2,131,500	20,300	330,750	3,150	155	18,500	176	8.7
Medium	Transfer	22	1,036,200 0	47,100	308,550	14,025	298	8,400	382	8.1
Large	Transfer	4	597,600	149,400	601,500	150,375	1,007	51,200	12,800	85.7

*D.C.MT - Metric ton of dry cleaning processed

TABLE A-2

ONTARIO DRY CLEANING INDUSTRY

ANNUAL SOLVENT LOSSES IN WASTE GENERATED BY TYPE OF WASTE [1]

SIZE	PROCESS	NUMBER OF PLANTS				SOLVENT IN WASTE (Kg)							
						TOTAL		STILL BOTTOM SLUDGES		FILTER MUCK		CARTRIDGES	
		TOTAL	/STILLS	* W/D.E. FILTERS	/CARTR. FILTERS	Total	per Plant	Total	per Plant	Total	per Plant	Total	per Plant
PERCHLOROETHYLENE		1,185	934	92	1,056	294,900	249	181,900	195	13,000	141	100,000	95
Small	Transfer	570	399	51	519	57,300	101	23,900	60	2,800	55	30,600	59
	Dry-to-Dry	352	289	18	303	42,200	120	28,900	100	900	50	12,400	41
	Fully-enclosed	28	21	0	28	5,900	211	2,000	95	0	1	3,900	139
		950	709	69	850	105,400	111	54,800	77	3,700	54	46,900	55
Medium	Transfer	110	107	3	107	99,900	908	58,000	542	100	33	41,800	391
	Dry-to-Dry	56	56	6	47	26,900	480	20,500	366	3,700	617	2,700	57
	Fully-enclosed	33	27	6	24	6,100	185	4,000	148	700	117	1,400	58
		199	190	15	178	132,900	668	82,500	434	4,500	300	45,900	258
Large	Transfer	17	16	6	11	14,800	871	7,700	481	3,500	583	3,600	327
	Dry-to-Dry	18	18	2	16	40,700	2,261	36,000	2,000	1,300	650	3,400	213
	Fully-enclosed	1	1	0	1	1,100	1,100	900	900	0	1	200	200
		36	35	8	28	56,600	1,572	44,600	1,274	4,800	600	7,200	257
PETROLEUM SOLVENT		131	62	39	110	78,100	596	39,500	637	16,400	0.2	22,200	0.6
Small	Transfer	105	53	32	84	18,500	176	9,300	175	1,600	50	7,600	90
Medium	Transfer	22	6	6	22	8,400	382	400	67	100	17	7,900	359
Large	Transfer	4	3	1	4	51,200	12,800	29,800	9,933	14,700	14,700	6,700	1,675

TABLE A-3

ONTARIO DRY CLEANING INDUSTRY

ANNUAL SOLVENT LOSSES IN WASTE GENERATED

BY DISPOSAL PRACTICE [1]

SIZE	TOTAL NO. OF PLANTS	TOTAL SOLVENT IN WASTE (Kg)	RECYCLED OR STOCKPILED (Kg)	LICENSED DISPOSAL (Kg)	UNLICENSED DISPOSAL (Kg)	LOSSES TO UNLICENSED DISPOSAL (%)
PERCHLOROETHYLENE	1,185	294,800	174,200	7,000	113,600	38.5
Small	950	105,400	48,100	1,400	55,900	53.0
Medium	199	132,900	81,500	100	51,300	38.6
Large	36	56,500	44,600	5,500	6,400	11.3
PETROLEUM SOLVENT	131	78,100	0	53,400	24,700	31.6
Small	105	18,500	0	4,300	14,200	76.8
Medium	22	8,400	0	1,600	6,800	81.0
Large	4	51,200	0	47,500	3,700	7.2

APPENDIX B

DESCRIPTIONS OF TECHNOLOGIES FOR REDUCING THE SOLVENT CONTENT OF DRY CLEANING WASTES

B.1 DISTILLATION

Distillation is a process where constituents of multi-component solutions/mixtures can be separated by transfer through the gas phase. In terms of a volatile solvent, this can be done through heating, vacuum, or other methods of controlling vapour pressure. Components brought into the gas phase are either condensed (cooling or pressure) or adsorbed (such as on activated carbon).

B.1.1 Sparging

A sparger is essentially a still which contains a module which can fit one or more cartridge filters. The module allows steam to be backflushed through the cartridge. This strips free solvent from the cartridge through heating, displacement, and gas flow in addition to azeotroping effects (see B.1.4) of the water (perc only). For cartridges containing activated carbon, the sparger acts as a conventional steam stripper, displacing and volatizing volatiles and leaving behind other contaminants. Regeneration of the activated carbon does not occur during sparging.

Some spargers can be also used as conventional stills and some have "steam sweep" features (see B.1.4). Specification sheets on two units are attached (for illustration only, not intended as endorsement).[7]

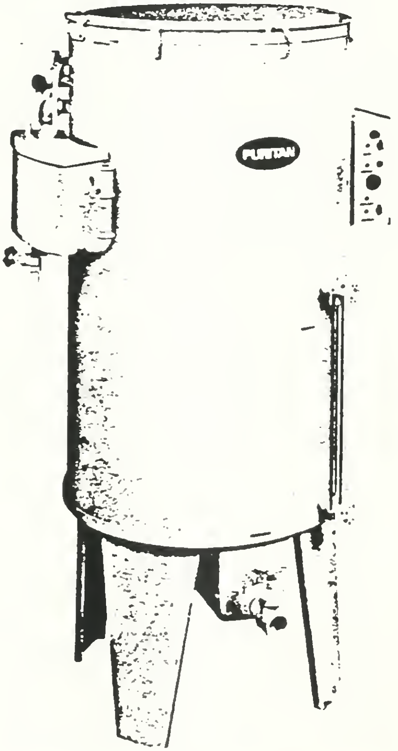
B.1.2 Conventional

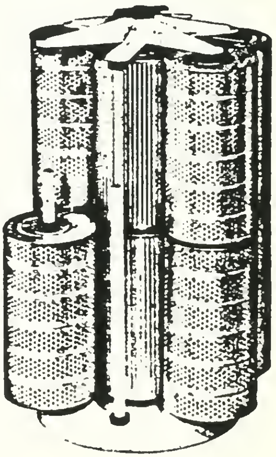
A conventional still heats a liquid mixture to its boiling point and maintains boiling temperatures throughout the separation process. Very useful in distilling non-flammable solvents, (e.g. perc) a conventional still can be dangerous when applied to flammable solvents (e.g. petroleum solvents). Use of conventional distillation with flammable solvents necessitates the use of an inert atmosphere.

BULLETIN NO. 1482

Puritan 4000
SOLVENT RECOVERY SYSTEM

for cost effective cartridge and still residue stripping and high performance distillation

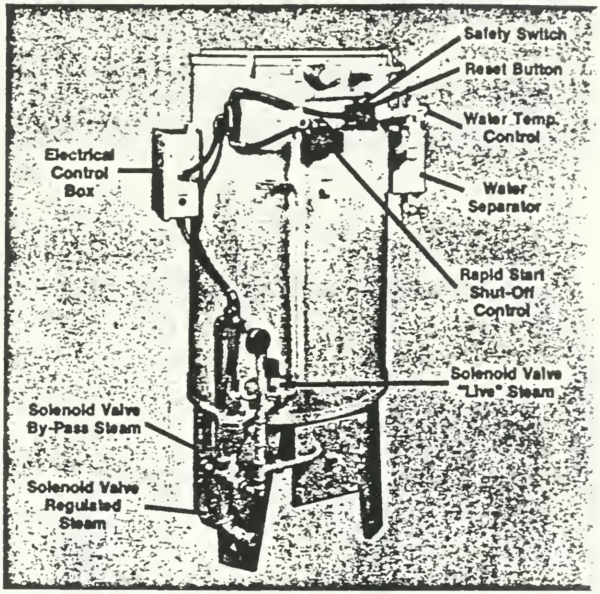




Removable sparging unit
for stripping perc
from cartridges.

PURITAN 4000 SOLVENT RECOVERY SYSTEM

for cost effective cartridge and still residue stripping and high performance distillation.


Safety Switch
Reset Button
Water Temp. Control
Electrical Control Box
Water Separator
Rapid Start Shut-Off Control
Solenoid Valve "Live" Steam
Solenoid Valve By-Pass Steam
Solenoid Valve Regulated Steam

Puritan is the modern automatic way of recovering solvent from cartridges and still residue.

New Puritan 4000 Solvent Recovery System is based on and includes the proven design features of Puritan stills, with several new high performance features added:

- Unique sparging unit for stripping 14 standard sized cartridges at a time
- Steam sweep for stripping still residue
- Easy-to-clean water separator,
- Automatic control of steam pressure and water temperature,
- Insulated for increased efficiency.

Sparging Unit Easily Removable so that the Puritan 4000 Solvent Recovery System can also function as a high performance still, with a distillation rate of 40 g.p.h.

PURITAN 4000 SOLVENT RECOVERY SYSTEM
(For Perchlorethylene Only)

Distillation Rate		40 g.p.h.
Cartridge Stripping Capacity		14 Cartridges at a time
Boiler Horsepower Required		1.6 Boiler HP
Normal Operating Steam Pressure		40 PSI
Dimensions	Width	32 Inches
	Depth	36 Inches
	Height*	62 Inches
(*Allow Additional 26" To Open Hinged Cover)		
Shipping Weight		550 Lbs.

PURITAN®

FILTER CARTRIDGES & CARTRIDGE FILTER SYSTEMS SERVICED BY STREET'S DRYCLEANING TECHNICIANS

R. R. STREET & CO INC
STREETS
OAK BROOK ILLINOIS U.S.A.

---

*Puritan is a registered trademark of R.R. Street & Co. Inc.

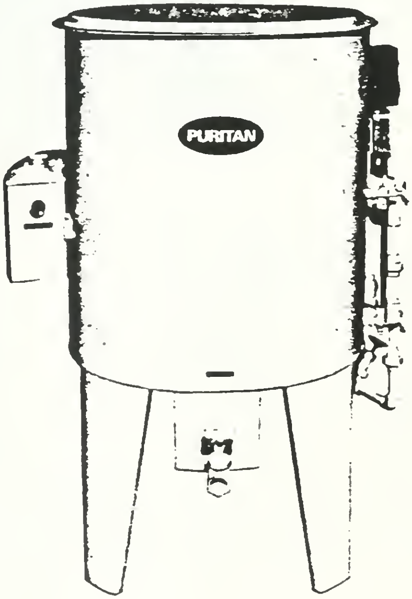
8/86

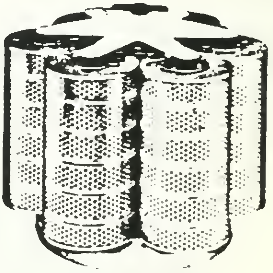
PRINTED IN U.S.A.

BULLETIN NO. 149

Puritan 2500-SRS SOLVENT RECOVERY SYSTEM

for economical cartridge and still residue stripping and high performance distillation





Removable sparging unit
for stripping perc
from cartridges.

PURITAN 2500-SRS SOLVENT RECOVERY SYSTEM

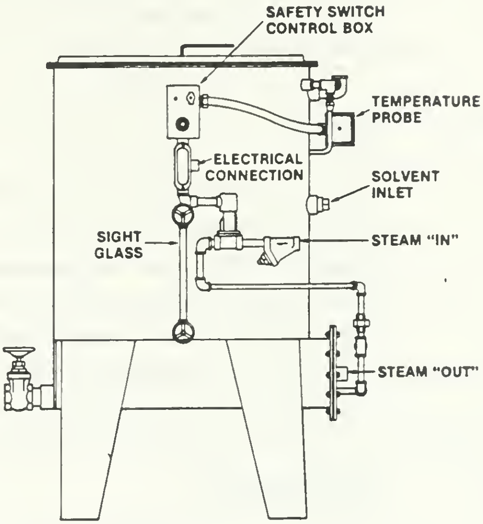
for economical cartridge and still residue stripping and high performance distillation

Puritan is the modem automatic way of recovering solvent from cartridges and still residue.

New Puritan 2500 Solvent Recovery System is based on and includes the proven design features of Puritan stills, with several new features added:

- Unique sparging unit for stripping 7 standard sized cartridges at a time,
- Steam sweep for stripping still residue,
- Easy-to-clean water separator,

Sparging Unit Easily Removable so that the Puritan 2500 Solvent Recovery System can also function as a high performance still, with a distillation rate of 20-25 g.p.h.



PURITAN 2500 SOLVENT RECOVERY SYSTEM
(For Perchlorethylene Only)

Distillation Rate		20-25 g.p.h.
Cartridge Stripping Capacity		7 Cartridges at a time
Boiler Horsepower Required		1.5 Boiler HP
Normal Operating Steam Pressure		30-35 PSI
Dimensions	Width	32 Inches
	Depth	32 Inches
	Height*	44 Inches
(*Allow Additional 26" To Open Hinged Cover)		
Shipping Weight		240 lbs.

PURITAN®

FILTER CARTRIDGES & CARTRIDGE FILTER SYSTEMS SERVICED BY STREET'S DRYCLEANING TECHNICIANS

R R STREET & CO INC
STREETS
OAK BROOK ILLINOIS USA

*Puritan is a registered trademark of R.R. Street & Co. Inc.
8/86

PRINTED IN U.S.A.

Conventional distillation poorly resolves mixtures of components of similar boiling point. Also, in general, as distillation proceeds, a temperature rise occurs.

B.1.3 Vacuum

Application of vacuum distillation instead of heat causes components to "boil off" at lower temperatures. It is particularly useful for flammable solvents or solvents which otherwise decompose at elevated temperatures. It also is very useful for separating components whose boiling points are similar but whose vapour pressure/temperature curves diverge. Vacuum distillation is often combined with heat to also give time advantages over vacuum alone or heat alone.

B.1.4 Sniffer/Cabinet

A sniffer or cabinet is a chamber where used (spent) filter cartridges are placed after removal from the dry cleaning process. Cartridges placed in such a unit are generally wet (saturated) with solvent. Room temperature air or hot air (perc only) is passed through the cabinet and exhaust air either vented or scrubbed with activated carbon. The sniffer/cabinet is generally applied to control solvent vapours in the workplace and where activated carbon is used can be a source of recovered solvent.[1, 18-20]

B.1.5 Azeotroping

Some multi-component mixtures will boil at temperatures between the boiling points of the pure substances. Where a gas-liquid mixture behaves like a pure substance we have an "azeotrope". The azeotropic boiling point for perc and water is about 88°C compared to 120°C for pure perc[1]. Thus, adding water to a conventional still allows the still to be operated at a lower temperature.

Mixtures can often be separated into their constituents by distillation. If however, a minimum appears in the vapour pressure curve, a corresponding minimum occurs in the boiling point curve. Such mixtures cannot be separated into their components by distillation. Boiling the mixture will always yield a vapour which has a constant ratio of the components - i.e. they are not separated. A liquid mixture which has a ratio of components equal to that in the vapour phase is called an "azeotrope" (from the Greek: to boil unchanged). Thus with perc, if water is added, and the mixture heated, a vapour mixture (azeotrope) is formed. The condensate of this vapour mixture will always have the same ratio of perc to water. The separation occurs because in the resulting "pure" two component mixture, perc is virtually insoluble in water and is 60% more dense. The separation of components occurs through gravity and decantation.

Two specific procedures for azeotroping have been explored by the IFI (in addition to sparging)[8, 13-16]. These are:

- Steam Sweep i.e. Sweeping live steam over filters or residues. This appears to work best on solids like paper (not carbon) or solid residues.

- Water Added. This is generally used for still bottoms and mucks. Water is added and distillation occurs. IFI found the best success in doing this twice (in sequence).

B.2 EXTRACTION

In extraction, components are separated without necessarily passing through the gas phase.

B.2.1 Vacuum Press

A vacuum press is simply a mechanical press which "squeezes" out liquid from a high-solids mixture. Vacuum is applied for the purpose of obtaining a pressure assist from atmospheric pressure in addition to transporting "squeezed" liquid. This would be most likely applicable to filter mucks or high-solids still bottom from petroleum solvent plants.

B.2.2 Solvent

In solvent extraction, a "solvent" is selected in which the component to be extracted is more soluble than in its present matrix. Solvent extractions often involve multi-stage, multi-solvent procedures. There appears to have been no study of this method in the dry cleaning industry.

B.2.3 Electrolytic/Catalytic Decomposition

One medium-sized dry cleaning chain has uncovered a novel technology from Europe[17]. It involves the use of a Magnesium "grounding rod" and packages of "magic powder". It is claimed that the powder reacts solely with the contaminants present in the Perc causing decomposition into simple water soluble compounds. Periodically, a (water) wet towel is tossed in for dry cleaning, the contaminants extract into the water in the towel, the towel is removed and laundered conventionally, and wastewater discharged to sewer. It is claimed that the sewer discharge meets by-law limits. It is also claimed that this process would make distillation unnecessary and possibly eliminate the need for carbon filtration.

While this may at first sound far-fetched, the possibility exists. Chlorinated solvents (i.e. Perc) are noted for their stability (i.e. lack of reactivity). If we classify the contaminants as oils and

:

fats, fatty-acids, odourous compounds (organo-sulfur, organo-amines, etc.), and dyes (azo-compounds), it is probable that a sufficiently "tuned" oxidation-reduction environment could cause selective decomposition of many of the non-chlorinated contaminants.

The method has been in use experimentally for a few months. It is worth closer investigation.

B.3 "HANDYMAN"

Handyman technologies would be described as active things that can be done to wastes to reduce solvent content without resorting to extensive engineering or purchased technology. In general, current on-site processes designed for dry cleaning of garments would be applied creatively to solvent reduction problems.

B.3.1 Cartridges

Because they are physically easier to handle, filter cartridges are the best candidates for handyman approaches.

The most attractive approach is to dry the spent cartridges in the process filter housing. Losses to atmosphere and exposure of employees to perc handling would be minimized. A by-pass piping loop would be necessary to allow the "sniffing" of the cartridges. Integrated sparging could also ultimately be designed into process filter housings. There is some indication that an engineered process unit with an in-housing sniffing feature is available.

Other handyman techniques revolve around placing spent filters in novel locations.

They can sometimes be placed in lint traps, in the tumbler (drier) units during hot air operation, in non-sparging stills, in conventional ovens (not recommended), in spin/drain units or pressure-liquid washed with water (likely not very effective).[1,2,7,8]

B.4 INCINERATION

Incineration is the complete oxidation (destruction) of an organic compound. This is accomplished by intense heat or catalytically. Petroleum solvent would be converted to CO_2 and water, Perc would be converted to CO_2 and hydrogen chloride.

B.4.1 Thermal

Thermal incineration utilizes high temperatures in the presence of excess air to combust an organic material. Petroleum solvent wastes are excellent candidates for thermal oxidation due to the high BTU contents and self-sustained combustion. Wastes can be blended with fuel oils in many cases and used for their heating value.

Perc wastes on the other hand cannot generally sustain combustion. Extremely high temperatures (such as cement kiln temperatures) are required and considerable added fuel.

Different thermal units (off-site) can handle liquids, sludges and broken (pelletized) solids. On-site units would only be suitable for liquids, large plants, and near-continuous feeds.

B.4.2 Catalytic

Catalytic incineration utilizes precious metal surfaces (e.g. Platinum, Palladium, etc.) to initiate oxidation of organic compounds. Catalyzed oxidation occurs at much lower temperatures, evolves smaller amounts of heat, and requires much less added fuel. Because of the requirement for intimate surface contact, this technique is generally only suitable for low-ash liquids and gases. In addition, high chlorinated contents can be problematic.

B.5 PASSIVE TECHNIQUES

Passive techniques can be defined as "low tech" methods utilizing natural forces over extended periods of time.

For example use of simple gravity can significantly reduce the solvent contents of some wastes. If spent cartridges are allowed to drain overnight before disposal, several litres of usable solvent can often be recovered (and not end up in the waste)[2,6,7]. If filter muck slurries are allowed to settle for a few days they can be decanted, thereby recovering useful solvent.[21,22]

Putting wastes "out in the air" to dry over a few days can also reduce the solvent content of the water. The down side of this is that air emissions will result and if done in the plant employee health could be impaired.

"Tossing cartridges on the roof" or putting out pails of other wastes in the sun to bake could similarly reduce solvent contents at little cost. But air emissions and politics may not permit such an approach.

Also, while a technique may significantly reduce the amount of solvent in a primary waste (e.g. 50% reduction) it may not be near good enough to permit the final waste to be handled and disposed of as non-hazardous.

B.6 OTHER TECHNIQUES

As pointed out in other sections, treatment processes can be expected to improve in efficiency as the scale increases. A central waste processing plant is capable of recovering, recycling, reusing or regenerating a larger proportion of the components of a cartridge than an individual dry cleaning plant. To appreciate why this is so, refer to the process description in Section C.1.

The problem with filter mucks for example is that there are insufficient quantities to warrant more than the odd muck cooker. Also muck cookers still produce hazardous residues. Collectively, filter muck volumes may not warrant dedicated central industrial reprocessing plants. In practice, filter mucks often are combined with still bottoms and the mixture disposed of as still bottoms.

In Germany the problem of petroleum solvent filter mucks has been dealt with in a novel way[12]. There, as in Ontario, quantities are large enough to warrant concern but too small to justify dedicated central processing. However, it has been observed in Germany that filter mucks from breweries are of similar quantities and compositions. The brewery application of diatomaceous earths presumably would be in process clarification and effluent filtration.

The German solution involves combining the diatomaceous earth (kieselgur) wastes from petroleum dry cleaners and breweries. The process is described in a publication in German[12]. (Without translation) it would appear that there is a primary slurrying stage for the wastes followed by injection into a rotary kiln. Kiln exhausts traverse a cyclone for primary recovery of the diatomaceous earth. Gases pass through a heat exchanger, condenser, and an electrostatic precipitator (ESP) prior to exhaust. Secondary recovery of the diatomaceous earth occurs at the ESP.

:

The diatomaceous earth would appear to be reusable in dry cleaning establishments and at least at the process effluent stage of the brewery.

Another process has been applied by Ontario Hydro to the removal of solvent from polyurethane insulation prior to disposal. This involves the use of microwaves to effect distillation. Its possible applicability to dry cleaning wastes is presently being investigated.[27,28] Ontario Hydro also utilizes conventional distillation to freon-residues in their dry cleaning operations at the Bruce Nuclear Power Plant.[26]

Environment Canada and the Canadian Standards Association are evaluating inclusion of the dry cleaning industry in an "environmentally friendly" logo licensing program. Presumably, those establishments using "best technologies" would be permitted to display the logo.[29,30]

APPENDIX C

EXISTING WASTE MANAGEMENT SYSTEMS SERVING THE DRY CLEANING INDUSTRY

The following discussion describes the operations of selected waste management systems.: This is done to illustrate how an existing company manages dry cleaning industry wastes. The selection does not imply endorsement of companies or systems described nor non-endorsement of companies or systems not-described.

C.1 FILTER CLEAN INC.

This company operates an integrated recovery/recycling facility serving the Florida dry cleaning industry. The facility strips solvent from cartridges, still bottoms, and filter mucks and recovers or regenerates many other constituents of these wastes.

The company has no direct contact with dry cleaners but deals with an industry supplier (Ashland). The supplier travels to dry cleaners to make deliveries and when warranted, returns with wastes. Wastes are bulked at transfer stations and transported to Tampa where the plant is located.

The company is interested in licensing a plant for construction in Ontario and establishing a similar relationship with suppliers.

A process description provided by Filter Clean follows (reproduced by permission).

They currently charge (i.e. Ashland charges) the dry cleaner $17 U.S. per standard cartridge picked up in Florida. The Florida operation serves about 1,000 dry cleaners.

TECHNOLOGY/PLANT AND EQUIMENT

The Company uses conventional steam stripping and distillation technology to recycle dry cleaning waste. These wastes vary dramatically in form, however, in substance the material stripped or distilled is perchloroethylene (perc). The variation in form is what makes dry cleaning waste difficult and expensive to process. The Company's recycling facility is unique and proprietary.

Dry cleaning waste can be categorized in three groups which are: filter cartridges, still bottom and filter muck. Filter cartridges come in three physical sizes and consist of perforated sheet metal, housing pleated filter paper with activated carbon or bentonite (clay) cores. Still bottom is a viscous liquid (about the consistency of used motor oil) containing water, perc and dirt. Filter muck is a slury consisting of diatomaceous earth, water, perc and dirt. The recycling process is designed to cover as much of the organic solvent (perc) as is practical. The solvent remaining in the waste materials after processing must be less than 1% by weight to allow disposal in a certified hazardous waste disposal site. As previously stated, perc is categorized as a hazardous substance (EPA #F002) since it is moderately toxic and a potential carcinogen. This solvent is a very stable, clear colorless, non-flammable liquid principally used in the dry cleaning process. It is also used for metal degreasing and the production of freons, adhesives, aerosols, paints and coatings.

Process units commercially available for recovering perc form used filter cartridges use a system of distributing steam through a manifold incorporating cartridge posts which hold the used cartridges. Steam passes outward from this perforated post at the center of the cartridge, through the carbon or clay core and filter paper media. The heat of the steam causes the perc in the cartridges to be vaporized just as in distillation. It typically takes four (4) minutes per cartridge to load and unload this type unit with recovery of 99.8% of the solvent at working pressure of 40 p.s.i. for 8 hours.

The Company's stripping unit is designed to receive shred filter cartridges, activated carbon or other solid wastes from a sealed conveyor system. The stripping vessel is constructed of stainless steel designed to operate at 100 p.s.i. pressures with temperatures ranging from 320°F up to 500°F (using superheating) for reactivation of carbon. The interior of the tank contains a stainless steel perforated cone. Dry steam enters through the bottom of this vessel passing through the cone and material to be stripped of solvent leaving through the top of the tank. As the steam passes through the material containing the solvent absorbate it undergoes desorption vaporizing the perc which flows continuously from the stripping vessel through the heat exchanger where they condense. The condensed steam and perc form an immiscible solution which is pumped through a liquid/liquid separator. Under operating conditions the two coalesced phases (aqueous and organic) will drain out of the separator as continuous streams. The water is reused by the boiler or cooling tower make up supply and the perc is stored in 55 gallon drums for resale.

Pressure and temperature are absolute factors affecting the efficiency of the desorption process. The Company's high presaure and temperature process will strip better than 99.8% of the solvent from the used filter paper within 10 minutes and reactivate the carbon to approximately 80% of its working capacity within 6 hours. The waste materials of the recycling process will contain less solvent (perc) per pound than a recently cleaned garment. It takes about 40 seconds per cartridge to remove the carbon core, shread, load and unload the cartridge from the stripping vessel. The Company's steam stripping unit is much more adaptive and efficient than the conventional systems designed to strip whole cartriges.

Distillation of still bottom and filter muck takes place in the Company's double walled stainless steel vessel which incorporates an internal scraper assembly and a highly sloped bottom containing a six-inch gate valve for discharge of highly solidified residuals. The steam heating jacket or external tank can operate at pressures of 125 p.s.i. yielding process temperatures of 340°F. The internal tank, which contains the process materials, is kept in a continous vacuum which effects the distillation to an extremely low level.

The Company's steam stripping and distillation units are mechanically simple in design. These systems have been reviewed for process integrity by John S. Jeter, P.E., chief engineer with Tampa Tank & Welding, Inc., an industry leader in chemical process tank design and manufacturing, and Ted L. Keller, President of Keller & Associates, Inc., a state certified mechanical contractor with over 15 years of experience in industrial steam generating and steam process equipment.

All wastes are fed to the thermal processing units from the system feed room. this 8x12 foot wood frame constructed room contains the shredding, conveying and pumping equipment necessary to transfer the assorted waste materials to the process units. The air in this room is continuously circulated through an organic vapor activated carbon absorption drum. This will maintain perc vapors well below the OSHA Permissible Exposure Limit (PEL) of 50 parts per million average concentration in the air over any 8 hour workshift. When the vapor absorbing carbon begins to become saturated, i.e., breakthrough starts to occur, it will be reactivated in the stripping unit. This will allow the expensive vapor phase activated carbon to be reused for 7 or more years while turning the vapors of the work environment into a marketable product (perc).

The entire recycling system is close-looped, that is it emits no vapors to the atmosphere and requires no connection to a domestic water and waste water service. All water used for steam generation and cooling water is continuously reused. The facility will be cleaner, less vaporous and easier to operate than a conventional dry cleaning plant. These abilities will allow the facility to be placed in most industrially zoned areas within a conventional warehouse.

C.2 DALEX CO. LTD.

Dalex is a supplier of dry cleaning equipment and supplies. Several years ago it initiated and instituted a waste management system for perchlorethylene still bottoms and mucks in Ontario. This is the reason the previous study (Beak, 1987) could report that 99% of perc still bottoms were well managed in Ontario.

Dalex has obtained licensed waste hauler registration for its drivers and operates a system whereby its drivers go out with supplies and, when warranted, come back with waste. They have also established a licensed waste transfer station at their Concord (Toronto) warehouse. Waste is bulked there for truck load shipment to Anachemia who performs the solvent recovery operation.

The containers used are metal drums in which dry cleaning additives are supplied (e.g. detergents).

Dalex currently charges $180/45 gal. drum, $130/24 gal. drum, and $95/12 gal. drum for pickup of still bottoms in Ontario.

Dalex has expressed interest in also establishing a filter cartridge management system for the industry.

C.3 SAFETY-KLEEN INC.

This company is in the business of waste reclamation. Regarding dry cleaners, the company currently handles all types of wastes in the U.S., Quebec, and the Maritimes. Containers are provided and are picked up on an agreed frequency. A retainer is charged for a minimum (or no) quantity. Additional quantities per period are charged additional fees. The company takes care of all special manifesting for each client and assumes all responsibility for the wastes on pickup.

Wastes are picked up by licensed haulers and taken to bulking/transfer stations. Wastes bulked in Ontario would be taken to Hebron, Ohio for recovery processing.

As a waste reclaimer (for other wastes), the company is very well established in Ontario.

In Quebec and the Maritimes, Safety-Kleen charges a $100 sign-up fee and a $60 retainer which covers pickup of up to one drum of waste every six weeks (16 U.S. gal/drum). Wastes can be mixed. There are additional charges of $16.50 per standard and $38 per jumbo cartridge. Additional drums are assessed at the $60 rate. Four standard cartridges fit in one drum.

APPENDIX D

REGULATORY CONSIDERATIONS

D.1 WASTEWATER

The previous study[1] indicated that most losses of solvent to the environment went to the atmosphere during dry cleaning operations (~90%). The present study deals with losses in disposed wastes. Losses occur also via wastewater.

It is difficult to estimate wastewater solvent losses and this is beyond the scope of this study. Some technologies for reducing the solvent content of wastes can lead to increased solvent loadings to wastewater. A brief "back-of-envelope" calculation can shed some light on how significant those losses to water would be.

The procedures of azeotroping perc with water in wastes, gives good solvent recoveries. The process depends on the relative insolubility of perc in water and the large differences in densities of the two compounds to separate the condensed azeotrope. The perc, however, does have some small solubility in water.

If we assume a worst case scenario of perc solubility in water of 100 mg/L (~ppm), and that all dry cleaners have effective interceptors such that only dissolved perc goes to wastewater discharge, the following estimate can be made (Table E-1).

When compared with existing losses via perc cartridges, clearly azeotroping losses via wastewater would be insignificant.

TABLE D-1

Perc Losses to Wastewater due to Azeotroping Distillation of Wastes

Assumptions	
PERC SOLUBILITY	100 mg/L
No. of perc dry cleaners using azeotroping	100%
Average water-added, once per week, per dry cleaner	4L
No. of perc dry cleaners	1,185
Amount of perc discharged once per week by average dry cleaner	100 X 4 = 400 mg
Amount of perc discharged per year by average dry cleaner	52 X 400 = 20,800 mg = 20.8 g
Total amount of perc discharged by dry cleaning industry per year	20.8 X 1,185 = 24,648 g 24.6 Kg
% of perc discharged to wastewater if all dry cleaners azeotroped compared to perc currently discharged in cartridge wastes (100,000 Kg - Table A-2)	$\frac{24.6}{100,000} \times 100$ = 0.025%

D.2 AIR EMISSIONS

If 90% of the perc used annually in the dry cleaning industry is lost to atmosphere there can be considered to be an air emissions problem. If we consider that air emissions are to some degree scavenged by water in clouds and via rainfall there could conceivably be a more significant impact on groundwater and surface waters from air emissions than from waste disposal.

While there are missing pieces of data, a rough calculation could follow the steps in Table D-2. A further study could estimate this impact.

In addition to water impact considerations, the atmospheric chemistry of perchloroethylene is by no means inconsequential. Impacts can occur relating to ozone formation and destruction at various elevations in the atmosphere, greenhouse gas impacts can occur, and formation of varyingly toxic organochlorine compounds occurs.

Occupational health concerns relating to worker exposure to the perc liquids and perc vapours have also not received appropriate attention.

The USEPA has concentrated its research efforts on air pollution control in the dry cleaning industry. As such, there is more literature dealing with air pollution control than with waste management.[3,4,11,18-20,23-25]

TABLE D-2

Perc Transport to Groundwater and Surface Waters via Cloud and Rainfall Scavenging of Air Emissions

Assumptions	
Annual Ontario Per Emissions to Atmosphere from Dry Cleaning Operations[1]	3,590,580 Kg
% of Perc Emissions scavenged to Clouds and rainfall	P %
Total Kg/yr. of perc transported to groundwater and surface waters	$\frac{P}{100} \times 3,590,580$
% of perc scavenged compared to perc currently discharged in cartridge wastes	$\frac{P}{100} \times \frac{3,590,580}{100,000} \times 100$

(100,000 Kg - Table A-2)

D.3 WASTE MANAGEMENT AND REGULATION 309

Disposal of perc wastes in non-hazardous landfills is currently illegal under Regulation 309. To stop this disposal, the existing Regulation needs to be enforced. To enforce the Regulation requires monitoring. Table E-3 explores the time logistics of such monitoring in the form of direct contact with the dry cleaning establishments and assumes that no problems are found.

Small-town and Northern Ontario establishments are at a disadvantage when it comes to transportation of small quantities of wastes. The U.S. EPA has addressed this problem there by relaxing the normal 90-day on-site storage restrictions to up to 270 days for small quantity generators (<1000 Kg./mo.). Implementation of such a scheme in Ontario would help to equalize waste management costs throughout the Province.

TABLE D-3

Monitoring of Dry Cleaning Establishments

Assumptions		
No. of visits per year by a Ministry Officer		1
No. of hours per visit:	1 - 2 hours on-site 0.5 - 1 hours transportation 1 hour correspondence	4
No. of dry cleaning establishments		1,200[1]
No. of Manhours for Ministry monitoring		1,200 X 4 X 1 = 4,800
No. of Manweeks @ 40 hrs. per week		$\frac{4,800}{40}$ = 120
No. of Manyears @ 52 weeks/yrs.		$\frac{120}{52}$ = 2.3